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MONTHLY NOTICES
OF THE
ROYAL ASTRONOMICAL SOCIETY,
CONTAINING
PAPERS,
ABSTRACTS OF PAPERS,
AND
REPORTS OF THE PROCEEDINGS
OF
THE SOCIETY,
FROM NOVEMBER 1860, TO JUNE 1861.

VOL. XXI.
BEING THE ANNUAL HALF-VOLUME OF THE MEMOIRS AND PROCEEDINGS
OF THE ROYAL ASTRONOMICAL SOCIETY.

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YSAVUL OROYNATZ

MONTHLY NOTICES
OF THE
ROYAL ASTRONOMICAL SOCIETY.

VOL. XXI.

Nov. 9, 1860.

No. 1.

The Rev. R. MAIN, President, in the Chair.

Walter Parsonson, Esq., Sheffield;
George Knott, Esq., Woodcroft, Cuckfield, Sussex;
Rev. H. Cooper Key, Stretton Rectory, Hereford; and
O. Pihl, Esq., Christiania, Sweden,

were balloted for and duly elected Fellows of the Society.

Account of Observations of the Total Solar Eclipse of 1860, July 18, made at Hereña, near Miranda de Ebro; with a notice of the general proceedings of "The Himalaya Expedition for Observation of the Total Solar Eclipse." By G. B. Airy, Esq., Astronomer Royal.

In placing before the Royal Astronomical Society an account of my observations of the Total Eclipse of the Sun, of 1860, July 18, it is not so much my own personal observations which I wish to convey, as an account of the general proceedings of a party who, I trust, will be distinguished in future times as associated under the title of "The Himalaya Expedition." And even of these I cannot profess, in this communication, to give the scientific observations. The number is far too great, (from persons either who sailed in the Himalaya, or who were connected with the expedition by friendly ties, I have already about sixty accounts); and the details too extensive. Moreover, in a subject where much of the value of the observations will depend on the comparison of different persons' observations, it may not improbably be found advantageous to break up each account, and to collect from all the different accounts; first, those parts which relate to one part of the phenomena; and

which will apply form one large chapter; secondly, those which relate to another part of the phenomena, and which will form a second chapter; and so on. I trust to be able hereafter to lay before the Society a comparative account of the observations, framed, probably, on these general principles. Omitting, then, for the present, the details of observations of the mass of observers, I will first give a short account of the expedition generally, and will then subjoin a few words only on my own observations.

Having had the honour of an interview with the Duke of Somerset, First Lord of the Admiralty, on 1859, Nov. 15, I took occasion to call His Grace's attention to the approaching total eclipse, and to submit to his consideration the advantage of appropriating to the use of astronomers a ship, for their conveyance to and from the coast of Spain. Although no answer could then be given to this proposal, the reception of it was so far favourable that I was induced to speak of it, in communications to this Society, as an arrangement which might be expected. Finally, the noble screw-steamship *Himalaya*, commanded by Captain Seccombe, R.N., was appointed for this service.

In the meantime the Society had received several communications, of a most friendly and very important character, from Charles Vignoles, Esq., whose position as Engineer-in-Chief of the Tudela and Bilbao Railway (the whole of which was to be covered by the shadow of the totality) not only gave him a thorough knowledge of the country, its points favourable for observation, its climate, and its social resources, but also enabled him to employ his own official powers and to use his good offices with the Directors of the Railway, particularly with their Managing Director, Señor Cipriano de Montesino, for giving to astronomers the assistance of the staff of able engineers stationed at different points of the railway. Offers of assistance, of a similar kind, were made by Philip E. Sewell, Esq., Engineer-in-Chief of the *Isabella Segunda* Railway, extending southward from Santander, to Alar del Rey. These invitations, in addition to other considerations, sufficed to define the course of the expedition. It was arranged that the *Himalaya* should first touch at the roads of Bilbao, landing there a portion of the party (in which I was myself included) who relied principally on the kindness of Mr. Vignoles for guidance in the selection of stations, and for aids to reach them; and that she should then proceed to Santander to land the remainder of the party, who would receive much assistance from Mr. Sewell. The ship would then lie in the harbour of Santander, and after the completion of the observations she would receive the Santander party, again touch at Bilbao to receive the Bilbao party, and finally return to England.

Mr. Vignoles, and other persons well acquainted with the climate, had strongly insisted on the danger (from the fear of cloudy skies) of remaining in the Biscayan provinces, and

urged that a large proportion, at least, of the observers should cross the Cantabrian Pyrenees into the valley of the Ebro. This arrangement implied an addition of at least two days to the time to be spent in Spain before the eclipse, and as much after the eclipse. It was also thought important to allow sufficient time for the transport of the heavy apparatus to be used by Mr. De La Rue, and for the erection of the temporary buildings in which he proposed to mount it. After consideration of these and other points, the morning of July 7 was fixed for the sailing of the *Himalaya* from Plymouth Sound.

At an early time I had addressed Lord John Russell, Her Majesty's Principal Secretary of State for the Foreign Department, requesting his intercession with the Spanish Government for such a degree of relaxation of the Police and Custom-house regulations as would permit astronomers to enter Spain with facility and without the charge of duty on their apparatus. In the correspondence which followed, I received letters from His Excellency Don Xavier e Isturiz, Ambassador of the Spanish Government; from Don Antonio Aguilar, Principal of the Observatory of Madrid; and from Don F. de P. Marqua, Principal of the Observatory of San Fernando, Cadiz; and in all of these I was abundantly assured of the interest taken by the Spanish Government in the enterprise, and of their determination to withdraw, for the benefit of astronomers, all the customary arrangements of ports and frontiers, which give trouble and expense to travellers.

The *Himalaya* sailed from Plymouth Sound, as was arranged, on the morning of July 7. The weather was fine, and the navigation generally agreeable. And nothing will ever efface, from the minds of those who had the pleasure to share in this voyage, the recollections of the kindness and courtesy of Captain Seccombe, R.N., commanding the ship; Lieutenant (now Captain) Versturm, First Lieutenant; John Thompson, Esq., Master; and the other officers of the *Himalaya*. The table and other accommodations provided by the Admiralty were most liberal, and every arrangement of the ship most comfortable.

In some conferences, on the deck of the *Himalaya*, an attempt was made to divide among the observers the different classes of observation.

The high land of Cape Machicaco was made early in the morning of July 9, and the *Himalaya* dropped her anchor in the roads of Bilbao a few hours later. Mr. Vignoles, accompanied by the principal officers of Customs and Police, and other departments, came out in a small steamer to receive and welcome the Bilbao party. The baggage and instruments were nominally examined in transit; the examination consisting, in reality, of lifting the lid of one open box. No passport was examined. The following is (I believe) a list of the party who landed at Bilbao:—

G. B. Airy, assisted by Wilfrid Airy.
 Rev. H. A. S. Atwood.
 Joseph Beck, assisted by Walter Beck.
 Joseph Bonomi.
 Warren De La Rue, assisted by E. Beck, Mr. Beckley, Mr. Downes, Mr. Reynolds.
 Francis Galton.
 Professor Grant.
 Charles Gray.
 Captain Jacob.
 Dr. M'Taggart.
 Rev. J. S. Perowne.
 J. G. Perry, accompanied by Professor Pole.
 Rev. C. Pritchard, assisted by V. Fasel.
 Russell Scott.
 Otto Struve, assisted by M. Oom and M. Winnecke.
 Rev. O. Vignoles.
 John Wright.
 Together with four ladies, namely Mrs. Airy, Mrs. O. Vignoles, Mademoiselle Struve, and Miss H. Airy.

The Himalaya then proceeded to Santander, and, on July 10, landed the following party:—

James Buckingham, assisted by W. Wray.
 H. S. Ellis.
 Professor Fearnley.
 Rev. H. A. Goodwin.
 R. F. Heath, assisted by J. Turner.
 R. J. Hobbes.
 W. Lassell.
 M. Lindelöf.
 Professor Lindhagen.
 E. J. Lowe, accompanied by Rev. W. R. Almond and Mr. S. Morley.
 Dr. Möller.
 J. Stanistreet.
 Professor Swan.

Of the Santander party I have at present no further account to give, and of the Bilbao party only the following. A kind reception from all parties awaited the astronomers on the Spanish land. The mayors of towns and villages, and the commandants of police, called on us and placed their powers at our disposal. On the day of the eclipse, the telegraphs were reserved for astronomical communications. But I am bound especially to say that the activity and entire self-devotion of Mr. Vignoles, his extensive private hospitality, and that of the gentlemen subordinate to him in the conduct of the Tudela and Bilbao Railway, contributed in a most important degree to the comfort of a large section of the observers, and to the success of their observations. To Mr. Bartlett, also, Resident Con-

tractor for the Railway works, we are indebted for much assistance.

Mr. Vignoles without delay despatched Mr. De La Rue's heavy instruments, &c., to the station which had been selected for him at Riva Bellosa, near Miranda. As early as possible the party were assembled at the offices of the Tudela and Bilbao Railway, and there, under the instructions of Mr. Vignoles and M. Montesino, a selection of stations was made. Omitting from this time allusion to other observers, the station allotted to M. Struve, M. Oom, M. Winnecke, and my own family party, was Pobes.* This is a very small and secluded village on the river Bayas, about two miles south of the remarkable defile of Tetches, where the Bayas issues from the Cantabrian Pyrenees. It is accessible by a good road in the direction of Orduña, Espejo, and Salinas (Anaña), as also by Vitoria and Nanclares. The Bayas, in its descent towards the Ebro, at the distance of little more than two miles, enters another defile, which is bordered on the eastern side by the hill above Hereña (called, I believe, St. Lorenzo), to be further mentioned in this account. The view from Pobes is therefore bounded on all sides by mountains, with the exception of a lateral depression on the eastern side of the valley, south of the Morillas hill, through which the mountains of the lower Ebro are seen. The church of Pobes stands on a steep knoll, perhaps 80 feet above the plain, and the churchyard surrounding it commands a very beautiful prospect.

At Pobes we were all placed under the hospitable care of Christopher Bennison, Esq., Superintendent of an extensive section of the Railway. And none of us will forget the kindness and the attention to all our wants, social and scientific, which we then experienced.

I arrived at Pobes, from Orduña, on the afternoon of Saturday July 14. On the northern side of the mountains the day had been dull and foggy, but on the south side the weather was extremely fine. I found my instruments arrived, and found Messrs. Struve, Oom, and Winnecke, engaged in astronomical observations for the determination of latitude and time. Their station for this purpose was a threshing-floor close to the churchyard. But I found that they had already selected points on the hills near Pobes, on the right bank of the Bayas, as stations for the observation of the eclipse. On viewing the country I had no hesitation in fixing on the hill above Hereña, on the left bank of the Bayas, as a very desirable post for myself.

I employed a part of the evening in endeavouring to judge (by memory) of the degree of darkness in a total eclipse. For this purpose I lighted a wax-candle, such as I had used in 1842 and 1851, and placed it on the parapet of the churchyard; and

* Pobes was the scene of some military movements immediately before the battle of Vitoria.

then, correcting my eye by its light, I remarked the time when, as I thought, the darkness appeared equal to that in the totality of 1851. It was about 8^h 30^m Greenwich mean solar time. Computing from this the position of the sun, it was about 7° 7' below the horizon. The evening was splendidly fine.

The next day, Sunday July 15, was magnificent. I went to the hill above Hereña, and found that it entirely satisfied my wishes. The point which I selected was the extreme eastern point, the highest part of the hill. The view of mountain and valley from this point is singularly grand. In the north-west direction, from which side the darkness would approach, the vision is limited at a few miles distance by the Pyrenees; but on the south-east side, in the direction of the retiring shadow, it extends across the Royal Road (from Vitoria to Miranda) and across and along the lower Ebro, to a very great distance. The south side of the hill is a bushy slope; the north side is a low crag of puddingstone, succeeded by a narrow flat and a talus, on which are numerous fine trees of the ilex, so common in that country, many of whose tops rise above the crag; and I could reckon with certainty on sheltering my telescope from any wind.

On the evening of July 15, finger-formed clouds began to show themselves in the north sky, and very soon there burst forth a thunder-and-lightning storm of great violence, which lasted all night. On July 16 and 17, the weather appeared completely changed. The wind blew from the north and was very cold; the near mountains were clouded very low; the distant mountains were invisible; the sun was not seen. The last-mentioned circumstance was unfortunate for me. I had prepared a telescope (constructed as I had previously explained to the Society) with a system of wires engraved on glass, containing, as an essential part, a square defined by crossing lines, within which square the image of the moon was to be brought. Pressure of business had prevented me from making many trials of this apparatus at Greenwich, but I had found that the dimensions of the square were a little too large for the sun, and I trusted that they would exactly correspond to the moon. In fact, they were a very little too large, and delicate manipulation was required for maintaining the moon exactly in the centre. I had relied on the climate of Spain for permitting me to acquire the necessary practice, when the sun should be near its meridian height on the two days preceding the eclipse; but in this hope I was totally deceived.

The morning of July 18 was cloudy; but distant mountains began to show themselves, and the aspect of the sky was improving. With the three companions of my own family whom I have mentioned, with Mr. Stead, one of the staff of railway engineers, and with nine men to carry instruments, I proceeded from Pobes to Hereña and up the hill. The weather steadily

improved, till before the eclipse began it was splendidly fine; a few clouds rather low in the south being all that was left of the late murkiness. My own telescope ($3\frac{1}{2}$ -inch aperture, 46 focal length, on tripod stand) was placed a few yards west of the end of the hill; the power used was about 50. The telescope used by Wilfrid Airy ($3\frac{1}{2}$ -inch aperture, 36 focal length, on tripod stand) was placed about twenty yards further west; the power used was about 100. I had a duplex watch, Molyneux 1007, beating $\frac{3}{4}$ seconds; Wilfrid Airy had a lever watch, Dent, beating $\frac{1}{4}$ seconds. The rest of the party had no telescopes or trustworthy watches.

Before giving the observations themselves, I will premise some numerical elements necessary for their reduction.

In comparing the observations made at numerous stations, it is evidently desirable to refer all the stations to a common system of geographical co-ordinates; and much of the clearness of our results may depend on the due choice of the system of co-ordinates. Now it appears evident that we want, not terrestrial longitudes and latitudes, but something which will show the relation of each observation to the following two elements,—first, the absolute time of the phenomenon; secondly, the nearest distance of the sun's centre from the moon's centre as seen at the place of observation. These elements are well connected with co-ordinates, of which the abscissa is measured along the central line of shadows, and the ordinate is measured along a line of simultaneous centrality of totality. The lines of which I speak are drawn upon Mr. Vignoles' map. I have therefore taken the measures from that map, using the minute of latitude as the unit of measure. For the zero of abscissa I have taken the western border of the map. The co-ordinates of Pobes, thus defined, are nearly,—

Abcissa 152; Ordinate 19 N.E.

A solar chronometer, Molyneux 2184, was carried from Greenwich. It was usually in the custody of M. Struve, and was undoubtedly treated with all possible care. Comparisons of its indications with Greenwich mean solar time were made before going and after returning, of which the following may here suffice:—

Molyneux 2184, slow on Greenwich Mean Solar Time:

		^h	^m	^s
1860,	June 23	0	2	5.0
	July 5	0	2	39.0
	July 30	0	4	2.4
	August 11	0	4	36.4

The mean daily rates in the three several groups are $2^{\circ}83$, $3^{\circ}34$, and $2^{\circ}83$. The agreement of these gives great confidence

in the uniformity of rate from July 5 to July 30. Adopting 3^h 34, we have the following results:—

Molyneux 2184, slow on Greenwich Mean Solar Time:

	^h	^m ^s
June 17	0	3 19.1
18	0	3 22.4
19	0	3 25.8

I am informed by M. Winnecke that the errors of the chronometer on Pobes mean solar time (as found by astronomical observation) at these epochs were 8^m 18^s.0, 8^m 15^s.1, 8^m 12^s.1, fast. These give for the longitude of the threshing-floor near the churchyard of Pobes 11^m 37^s.1, 11^m 37^s.5, 11^m 37^s.9. Its latitude was found to be 42° 48' 5".

Again we have,

Molyneux 2184, slow on Greenwich Mean Solar Time:

	^h	^m ^s
June 17	22	3 22.1
18	22	3 25.5

At these times, Molyneux 1007 was faster by 2^m 46^s.4 and 2^m 52^s.5; and Dent was slower by 15^m 56^s.0 and 17^m 9^s.5. From these we find with sufficient approximation, at July 18, 2^h to 4^h,

Molyneux 1007, slow on Greenwich Mean Solar Time	^m ^s
Dent slow	19 31
	to 19 37

Finally, as it was my intention to refer angles to wires in the telescope having a definite relation to the vertical, it was necessary to ascertain the angle made by the vertical with the astronomical meridian. On calculation it appears that the angles were,

At	^h	^m	Greenwich Mean Solar Time	^p [']
2 50				46 39
3 0	...	...	...	47 41
3 20	...	...	...	48 35

During the 3¹^m of totality, this angle therefore changed by about 19'; a quantity smaller than I could answer for in my observations, but which in more delicate measures ought not to be omitted.

I shall now proceed with my observations.

For observations of time, I commenced counting the $\frac{2}{3}$ beats of my watch at some decade of seconds, and counted up to 25 (=10^s), after which I again began counting. Thus I observed the first contact at 1^h 47^m 30^s of Molyneux 1007. My eye, however, was directed (in consequence, as I have since found,

of an error in the position of my wires) to a point on the sun's limb about 5° too high; and in consequence I did not perceive the very first contact. I think that it had taken place about 4° before the time noted. This gives for watch-time $1^{\text{h}} 47^{\text{m}} 26^{\text{s}}$, or for Greenwich mean solar time $1^{\text{h}} 48^{\text{m}} 1^{\text{s}}$; which I consider very exact.

On the progress of the eclipse I have nothing to remark, except that I thought the singular darkening of the landscape, whose character is peculiar to an eclipse, to be sadder than usual. The cause of this peculiar character I conceive to be, the diminution of light on the higher strata of air. When the sun is heavily clouded, still the upper atmosphere is brilliantly illuminated, and the diffused light which comes from it is agreeable to the eye. But when the sun is partially eclipsed, the illumination of the atmosphere for many miles round is also diminished, and the eye is oppressed by the absence of the light which usually comes from it.

I had a wax-candle lighted in a lantern, as I have had at preceding total eclipses. Correcting the appreciations of my eye by reference to this, I found that the darkness of the approaching totality was much less striking than in the eclipses of 1842 and 1851. In my anxiety to lose nothing at the telescope I did not see the approach of the dark shadow through the air; but, from what I afterwards saw of its retreat, I am sure that it must have been very awful.

At $2^{\text{h}} 59^{\text{m}} 30^{\text{s}}$ of my watch I commenced counting the beats, holding the watch to my ear, and recommencing the counting at the end of 25 beats. When, from the narrowness of the sun's lune, I judged that the totality would occur in ten or fifteen seconds, I withdrew the graduated coloured glass. To my infinite astonishment, while the white sun was still shining brilliantly, I saw in great splendour two red prominences (possibly more than two were visible) and one double floating red cloud. I am not certain whether the red sierra was then visible, or whether it became visible after the white disk had disappeared. But, before the white disk had disappeared, the white corona formed round the moon, I think all at once; and the moon was seen complete, with dazzling sun, brilliant corona, and brilliant prominences. The intensity of light in the corona and prominences was not much increased at the total disappearance of the sun.

The co-existence of all these lights really introduced much confusion in the observation of the time of formation of totality. I found myself counting the beats of my watch up to 45, and I set down the time of totality as $2^{\text{h}} 59^{\text{m}} 30^{\text{s}} + 45$ beats. But I was afterwards under the impression, and now fully believe, that I had passed one counting of 25 beats; so that the register ought to have been $2^{\text{h}} 59^{\text{m}} 30^{\text{s}} + 70$ beats. This makes the time $2^{\text{h}} 59^{\text{m}} 58^{\text{s}}$ of my watch, or $3^{\text{h}} 0^{\text{m}} 33^{\text{s}}$ Greenwich mean solar time.

In a former communication to the Society I stated my intention to use a system of wires embodying the following conditions: 1. That there should be a square, pretty exactly containing the moon; 2. That there should be a system of 12 crossing lines, or 24 radii passing through the centre of the square, and inclined each to its neighbour at an angle of 15° ; 3. That two of these crossing lines should be stronger than the rest, one approximately in the direction in which it was found (by calculation) that the moon would apparently cross the sun, the other in the direction normal to that crossing motion. And I proposed to observe the angular position of any prominences which might be near to the normal line. Mr. James Simms had furnished me with a reflecting eye-piece taking a definite position (as to angular rotation) in the telescope, and bearing such a system of lines etched on the reflecting prism; the position of the strong normal line being a few degrees in error. On bringing the moon into the square I found that there were two appearances which precisely corresponded to my wishes; one a prominence exactly 15° to the apparent left (or on the radius whose angle, measuring from the upper normal in direction of watch-hand-motion, is 345°); the other the double floating cloud, exactly 15° to the apparent right; both being bisected by the radial lines. A third large and conspicuous prominence more to the left, at perhaps 300° , I merely saw with a single glance. There might be others which I did not remark.

[I may take this opportunity of stating that the colour of these appearances was not identical with that which I saw both in 1842 and 1851. The quality of the colour was precisely the same (full blush-red, or nearly lake), but it was diluted with white, and more diluted at the root of the prominences close to the moon's limb than in the most elevated points.]

I proceeded as soon as I could with my measures (to be given below). About the middle of the totality I ceased for a while, in order to view the prospect with the naked eye. The general light appeared to me much greater than in the eclipses of 1842 and 1851 (one cloudy, the other hazy), perhaps ten times as great; I believe that I could have read a chronometer-face at the distance of 12 inches; nevertheless, it was not easy to walk where the ground was in the least uneven, and much attention to the footing was necessary. The outlines of the mountains were clear, but all distances were totally lost; they were in fact an undivided mass of black, to within a small distance of the spectator. Above these, to the height perhaps of six or eight degrees, and especially remarkable on the north side, was a brilliant yellow or orange sky, without any trace of the lovely blush which I saw in 1851. Higher still the sky was moderately dark, but not so dark as in the former eclipses. The corona gave a considerable body of light; I did not

remark, either by eye-view or by telescopic view, any thing annular in its structure; it appeared to me to resemble, with some irregularities (as I stated in 1851), the ornament round a compass card. But the thing which most struck me was the great brilliancy of *Jupiter* and *Procyon* so near to the sun. It was impossible that they could have been seen at all, except under the circumstance of total absence of illumination on that part of the atmosphere through which their light passed.

I returned to my measures, but I was soon surprised by the appearance of the scarlet sierra announcing the approach of the sun's limb. It disappointed me, for I had reckoned on a much longer time. All our party who were aware of the predicted duration fully believed that it must have been very erroneous. How the time had passed I cannot tell. The sun at length appeared, extinguishing the sierra, but the prominence and cloud remained visible, and my last measures were taken after reappearance. The prominence, &c., were then rapidly fading, and I quitted the telescope, not without the feeling that I had not done all that I had intended or hoped to do.

I looked around me, and in the southeast direction and for some time, perhaps ten seconds, I saw nothing remarkable in the atmosphere. About that time, as the light about me grew stronger, the darkness in the south-west attracted attention, and before long it looked as if the very air on that side was composed of blackness and opacity. The mountains along the Ebro were totally lost. A full half-minute passed, I think, before the darkness had so far diminished as not to produce the dominating impression of the scene.

My companions saw nine celestial objects, eight of which were identified by means of Mr. Hind's chart, and the ninth by our knowledge of its position. They appeared to be (using Mr. Hind's numbers of reference), 2 *Regulus*, 3 *Saturn*, 4 *Mercury*, 6 *Procyon*, 7 *Jupiter*, 8 *Venus*, 9 *Pollux* or 11 *Castor*, (not quite certain), 13 *Capella*, and *Arcturus*. *Sirius* and *Orionis* were hidden by clouds.

I now proceed with my measures. I must premise that I used a reflecting eyepiece, and therefore my image was erect with regard to up and down, and inverted with regard to right and left. My angular measures, which were made in the direction of watch-hand-motion, must be interpreted as made in the opposite direction. The strong normal line which was my zero of angle, was inclined, its upper part apparently to the left or really to the right, by about $9\frac{1}{2}^{\circ}$, and that quantity must be subtracted from all measures in order to refer them to the upper vertical. Finally, the angle $47^{\circ} 50'$ (found above) must be added (making the entire correction $38^{\circ} 20'$ additive) in order to refer the measures to the north meridian. The following are the measures as recorded; the angles being expressed by number of wire (which is to be multiplied by 15°) and by fractions of intervals of wires (or fractions of 15°). The

number of observations, it is conceived, divide the time into nearly equal parts:—

No. 1	Prominence.	Cloud.
	Measure lost in observing the time.	
2	$23^d + \frac{1}{6}$ interval.	$1^st + \frac{1}{6}$ interval.
3	$23^d - \frac{1}{5}$	$1^st + \frac{1}{5}$
4	Measure lost in quitting the telescope.	
5	Measure lost in quitting the telescope.	
6	$23^d - \frac{1}{5}$	$1^st + \frac{1}{5}$
7	$23^d + 0$	$1^st + \text{very little.}$

or the angles from north meridian, measured in the direction opposite to watch-hand-motion, are,

No. 1	Prominence.	Cloud.
	° ' "	° ' "
2	25 50	55 50
3	20 20	56 20
4	...	...
5	...	...
6	20 20	56 20
7	23 20	53 20 +

I left the telescope with the impression that the angles here measured had decidedly and distinctly decreased; and so, on the whole, it appears from the numbers, but not incontrovertibly. I wish that I had been provided with better means for delicate motion of the telescope than the rack-and-pinion of the steadying rods.

The end of the eclipse was at $4^h 9^m 14^s$ by my watch, or $4^h 9^m 49^s$ Greenwich mean solar time, pretty good.

Perhaps the following remarks on the progress made in the observation of successive eclipses may not be without value:—

In 1842, I, with all the rest of the astronomical world, was taken by surprise with the appearance of red projections. In 1851, various important observations of the elevations of projections were made: I cite M. O. Struve's micrometrical measures as the most valuable, and I should be glad if my own general observations of disappearance on one side and non-appearance on the other side were thought useful. One observer (I think not more) obtained a good measure of angular position. In succeeding observations which have been made in different parts of the earth, I think that no novelty has been introduced. In 1860 we have got not only good angular posi-

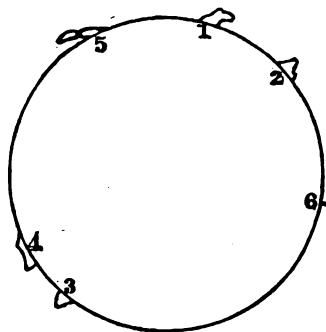
tions, but also fair attempts at measure of change of angle; and this will be seen more distinctly when the results deducible from Mr. De La Rue's photographs shall be published.

It is scarcely possible that I should observe a fourth total eclipse, and I can therefore only offer to future observers the advice upon which I should have acted myself. Whatever be the trouble and expense, and however small the chance of success in the observation, *use a good steady equatoreal, driven by good clockwork, and having easy transversal adjustments for the wire-frame.* With the system of wires that I have used (and which is described in the *Monthly Notices* for 1860, March 9, pp. 187, 188) I am well satisfied.

I extract the following notices from the accounts of my companions.

Wilfrid Airy observed the commencement of totality at $2^h 40^m 1^s$ by his watch, with the remark that, in consequence of a want of correspondence between the minute-hand and the second-hand, there might be an apparent error of 1^m . The application of the reduction computed above gives for the equivalent in Greenwich mean solar time, $2^h 59^m 35^s$; which, as compared with my observation, appears to be 1^m too small, but in other respects agrees closely.

By one of those inadvertencies which oppressed almost every observer during the excitement of the eclipse, Wilfrid Airy forgot to withdraw the coloured glass from the eye-piece, and actually observed the red prominences through it. This must be borne in mind as qualifying some of the statements that follow. "As soon as the totality commenced, the red prominences became visible, but I did not observe them before the totality. I did not notice the corona at all through the



telescope. The appearance and position of the prominences were as follows:—[the drawing, from the reversed image, being again reversed here to form a correct image.]

"Prominences 1, 2, 3 seemed to appear all at the same

moment; and 4 might have appeared also at the same time, but I did not notice it so soon. Prominence 5 did not appear till after the others, and was at first extremely hazy, but gradually thickened as the moon passed on. Prominence 4 disappeared about 1^m after the formation of totality, and I did not see it again. After the sun had burst forth, I noticed a prominence which would have been somewhere about 6; and this, as well as 1 and 2, I could see 2^m after the sun had reappeared. (I did not notice 6 before the sun reappeared, because I had left the telescope.) The colour of the prominences was a bright rose-colour, and 4 was brighter than 1, 2, and 3. Prominence 5 was lighter a good deal than the others.

"The stars that I noticed were *Jupiter, Mercury, Regulus, Saturn, and Arcturus*. *Arcturus* was bright. I saw no stars to the west of the sun."

[1 and 5 are the two objects whose positions I measured. It appears that Wilfrid Airy saw 5 as a prominence; whereas I, and also Mrs. Airy, who looked into my telescope, saw it as a floating cloud. 2 is the other prominence, which I saw in a glance.]

Wilfrid Airy saw the termination of eclipse at 3^h 50^m 4^s₁ by his watch, or 4^h 9^m 41^s Greenwich mean solar time, with the same caution as to possible error of 1^m.

From Mrs. Airy's notes I extract the following:—

"At last [some time after commencement] the light began to be sobered, like that of a summer evening, and soon a gloominess began gradually to creep over the whole scene, as if a storm were coming on. The southern mountains beyond the Ebro began to stand up strangely black. Then a sickly green hue began to creep over the whole nearer landscape. A peculiarly mournful sighing wind, cold and strong, began to rise as if from among the large old trees beneath us on the north side of the hill; and, looking down among them from the edge above, their dark green masses became every moment of a deeper green tinge, while the white old trunks gleamed whiter still. The butterflies disappeared, but the swifts continued on the wing. These appearances grew more and more intense, and all 'instructions' were totally forgotten in the excitement of the moment. It became very cold, and I was glad to wrap myself up in a large Scotch plaid. . . . The crescent diminished to a thread, the gloom everywhere intense. I was particularly struck with the moaning of the wind among the old forest-trees beneath me. The swifts had now disappeared. A deeper gloom filled the sky in the north-west, and came sweeping rapidly on. The moment of totality had come: the whole air was at once filled with darkness, yet it was darkness through which mountain and valley could be distinctly seen. To me it seemed as if we were in the midst of a streaky shower of smoke or fine dust, which, however, was perfectly clear, and which

could not be felt. It was only for a moment that I was struck with this appearance sweeping along the valley between us and the northern hills. The range of southern hills was of an inky black, while the sky beyond them was an intense golden orange. I have often seen a similar, though much fainter, effect in watching a fine summer sunset from the Greenwich Observatory through the smoke of London, when the air has been dry and the smoke very thin. These glorious colours were quite a new feature to me, for at the eclipse of 1842 the sky was entirely clouded. My shadow on the ground was quite black and sharp: the effect was like that of clearest moonlight. I could see the whole country, but I had to stoop in order to see my footing among the stones and shrubs. At the critical moment I forgot to remove the dark glass from my eye, and thus lost what I remember to have been the most striking phase of the whole phenomenon on the former occasion, viz. the starting out of the corona on the right side before the last thread-like crescent of the sun had disappeared on the left side of the moon. On that occasion, however (1842), it was a narrow fringe or border round the moon of soft light, of a uniform breadth, and slightly beaming texture, soon graduating into the darkness outside; while now it was a bright radiating glory of much wider extent, and its appearance made very singular from the projection of four or five brilliant beams at about equal intervals, far beyond the width of all the rest. I saw three bright stars near the sun; I could not, with the unarmed eye, see the red prominences. I looked for a few seconds in the telescope, and then I did see two of these wonderful appearances, but so faint in comparison with those of 1842 that for a moment I did not recognise them. One was a floating cloud, quite separate from and suspended over the upper edge of the moon, nearly divided into two parts by an indent below, of so pale a colour that at first it seemed almost white; but as I looked at it more steadily I perceived that it was of a pale rose-colour, the colour deepest against the upper edge, which was well defined, and becoming gradually paler to the lower indented edge. The other was lower down the edge of the left side of the moon, and not separated from it, but rising from it like those of 1842—a broad cone, cloven at the top; its colour was pale, like the other, and, like the other, it had a cloudlike and not a solid appearance."

At the reappearance of the sun, "We saw the dark shadow distinctly sweeping away along the valley to the south-east, a path of darkness, and the clear daylight breaking out behind it."

We descended from our hill-station, and on our way to Pobes we had the satisfaction of learning that M. Struve had been successful in his observations; and in no long time we were gratified by the intelligence that Mr. De La Rue's photographic operations during the totality had entirely answered to

his wishes. On July 20, I had the pleasure of visiting Mr. De La Rue at his station at Riva Bellosa; and, in admiring his observing establishment, I was much struck with the importance of his elaborate preliminary arrangements, in providing a first-class instrument, and carefully training his assistants; to which preparations his success is entirely to be attributed. On July 21, I, with my party, quitted the house of our most hospitable friend Mr. Bennison, for Vitoria, where I had the advantage of meeting Professor Mädler and M. Hermann Goldschmidt. I received here a telegraphic invitation from the Spanish Government, conveyed personally by the Secretary of the Governor of Viscaya, to join an Eclipse Congress at Madrid: the distance, however, and the pressure of home engagements, made it impossible for me to accept it. On July 22, we were again welcomed by our unwearied friend Mr. Vignoles, at Bilbao.

At our landing from the Himalaya, on July 9, it had been arranged that the ship should leave Santander for her return on the evening of July 23, and leave Bilbao on July 24. It now appeared, however, that the great festival of St. Jago, the patron saint of Spain, occurring on July 25, was to be celebrated by a bull-fight at Santander. In order to show our respect to a people from whom we had received so many marks of kindness, as well as to secure a longer time for collecting instruments, &c., the ship, at my request, was detained at Santander till the night of July 25, by which time all the Santander party had come on board. She lay the whole of July 26 in the roads of Bilbao, visited by many of the inhabitants. The Bilbao observers joined on that evening, and the vessel sailed immediately. We had left a few of our party, who proposed to return by land; their places were occupied by Mr. Vignoles, M. Montesino, Professor Chevalier, Mr. Wilson, and Professor von Weyer.

Many were the accounts of success and of misfortune to be told. It was matter of universal sorrow that the best friend of the expedition, Mr. Vignoles, had failed to see the eclipse. The Bilbao party had, for the most part, been successful; the Santander party, for the most part, were unsuccessful. Among these we were sorry to learn that our respected Fellow, Mr. Lassell, was to be numbered. After a most agreeable voyage, we anchored at Spithead about 4 P.M. on July 28, and landed in time for the railway-train which reached London on the evening of that day.

An account of the phenomena of the total eclipse as observed, under very favourable circumstances, at Burgos, was received from T. C. Janson.

Eclipse of the Sun, July 18, 1860. Observed at the Royal Observatory, Greenwich.

(Communicated by the Astronomer Royal.)

Observer.	Mean Solar Time of Observation.					
	First Contact.			Last Contact.		
	h	m	s	h	m	s
M.	1	39	26.4 (a)	3	54	2.8 (b)
G.	1	39	30 (c)	3	53	57 (d)
D.	1	39	30.0 (e)	3	54	6.7 (f)
E.	1	39	34.0 (g)	3	54	1.0
J. C.	1	39	24.6 (h)	3	54	7.2 (i)

(a), (h), The time noted is that at which the sun's limb was first indented by a prominence in the moon. (b), (f), (i), Satisfactory. (c), Considered within a second of the truth. (d), Not so accurate as the observation of the first contact. (e), The moon's limb very mountainous at the point of contact. (g), Two or three seconds previously to the time noted, the sun's limb was indented by two prominences.

The initials M., G., D., E., and J. C., are those of Mr. Main, Mr. Glaisher, Mr. Dunkin, Mr. Ellis, and Mr. Carpenter.

The following accounts of the Eclipse, as observed in England, have also been received:—

Eclipse of the Sun, July 18, 1860.

Observed at Greenwich Hospital, by John Riddle, Esq.

The eclipse had commenced some seconds before it was observed at 1^h 39^m 5^s.

The approach of the moon's limb to the spots marked in the diagram was well marked; the observations remarkably satisfactory.

Spot.

	h	m	s
No. 2. The first with which the limb came in contact, disappeared at	1	53	47.5
No. 3. First contact with large spot in Group A	...	...	1 55 4
No. 4. Extremity of large spot disappeared	...	...	1 55 37
No. 5. Disappearance of spot	...	...	1 56 36
No. 6. Final disappearance of penumbra	...	...	1 56 43
No. 7. Disappeared at	...	...	2 1 43
No. 8. „	...	...	2 2 6.5
No. 9. „	...	...	2 2 25
No. 10. Well-defined small spot	...	...	2 6 24.5
No. 11. „	...	...	2 25 15.5

B

A faint group followed, but offered no salient points for observation with the telescope employed.

No. 12 is a large double spot with a well-defined penumbra. Observed in the following order:—

	^h	^m	^s
1. Penumbra, 1st contact	2	36	13·5
2. 1st contact with spot	2	36	30·5
3. Middle space reached	2	36	38·5
4. Extremity of spot disappeared	2	36	56

Next came the small spot marked

No. 13.	...	...	...	...	...	...	^h	^m	^s
							2	37	35·5

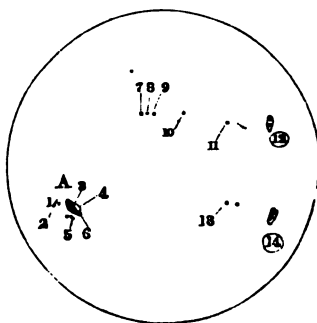
The following small spot was lost.

The larger group marked No. 14 was admirably well defined and observed as follows:—

	^h	^m	^s
1. First contact with penumbra	2	44	40
2. First contact, upper spot	2	45	4
3. Spot disappeared	...	2	45 17·5
4. First contact, lower spot	2	45	33
5. Spot disappeared	...	2	45 45·5
6. Penumbra	..	...	2 45 52·5

The reappearances of the spots were confined to the complete reappearance of Group A at 3^h 0^m 32^s, observed by Mr. Mugridge; and spot No. 10 at 3^h 16^m 38^s·5.

Telescope 2 ft. 8 in.; aperture 2·6 in.; power 40.



Sketch of the Spots on the Sun during the Eclipse of the Sun, July 18, 1860.

Greenwich Hospital, July 18, 1860.

Observed at Greenwich, by Rev. Geo. Fisher, M.A. F.R.S.

1. Sextant measures and distances of cusps.
2. Breadth of illumined portion of solar disk at right angles to the line of cusps.
3. Times of commencement and end of eclipse.

Time, Chronometer.	Dist. of Cusps.	Time, Chronometer.	Dist. of Cusps.
^h ^m ^s	['] ["]	^h ^m ^s	['] ["]
9 46 9	23 15	10 33 17	31 35
9 47 11	23 20	10 35 20	31 25
9 48 52	25 15	10 40 52	31 10
9 50 21	26 15	10 42 8	32 0
9 55 46	26 30	10 43 10	31 15
9 57 1	26 50	10 44 12	32 10
9 58 12	26 55	10 45 10	31 10
9 59 25	27 15	10 55 47	30 15
10 4 54	29 5	10 57 11	30 10
10 6 3	29 30	10 58 25	30 20
10 7 1	28 45	10 59 27	30 30
10 9 0	29 15	11 4 40	29 20
10 14 13	30 20	11 5 52	29 5
10 15 30	30 30	11 7 11	28 15
10 17 37	30 30	11 27 37	19 30
10 22 32	30 30	11 28 55	18 35
10 24 18	31 15	11 30 0	18 20
10 26 17	31 15	11 35 20	13 20
10 27 16	32 0	11 36 41	13 30
10 30 30	31 55	11 37 26	12 45
10 31 57	31 25		

Time, Chronometer.	Greatest Breadth of Illumined Portion of Disk.	Time, Chronometer.	Greatest Breadth of Illumined Portion of Disk.
^h ^m ^s	['] ["]	^h ^m ^s	['] ["]
10 36 10	5 0	10 49 30	7 30
10 37 48	4 45	11 0 46	12 40
10 39 14	5 0	11 2 5	13 5
10 46 25	7 0	11 3 10	14 0
10 47 35	7 15	11 8 17	16 15

The foregoing measures were taken by myself with an 8-inch sextant at the Greenwich Hospital School Observatory. They are given as read off from the instrument, without the omission of a single observation, and require 34" to be taken from each for index-error, which was determined with great care before and after the observations.

The times were observed with a chronometer going sidereal time, and require each to be increased by 18", the quantity

which the chronometer was slow of sidereal time, as determined by comparisons with the transit-clock before and after observations, both comparisons agreeing.

Although the weather was occasionally cloudy, yet the measures were taken under favourable circumstances, and accord with each other as nearly as can be expected in single sextant observations.

The commencement and end of the eclipse were also observed under favourable circumstances with a 40-inch equatorial of 3-inch object-glass, power 45, as follows:—

	Sid. Time.	M. S. Time.
	^h ^m ^s	^h ^m ^s
Commencement	9 26 3	1 39 43
End	11 40 37	8 53 54

As a very slight impression upon the sun's limb was made when the time of the commencement was recorded, perhaps about 1 or at most 2 seconds of time might be subtracted from the time here given, making the mean sidereal time of commencement $1^h 39^m 41^s$, instead of $1^h 39^m 43^s$.

Latitude $51^{\circ} 28' 50''$ N.; Longitude $0^{\circ} 2$ W.

Greenwich Hospital Schools, July 19, 1860.

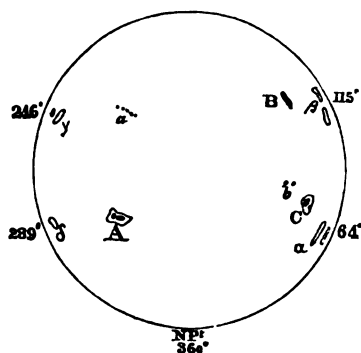
Observed at Maresfield, Sussex, by Captain Noble.

For some two hours prior to the moment of first contact I was occupied in the delineation of the map of the sun, which accompanies this paper, and which represents that luminary at a mean epoch of July 18th, 1^h G.M.T. Reference to the key to the larger drawing will show that I have lettered the three large maculæ in the order of their right ascension, A, B, and C; the minute groups I have called *a* and *b*; and the four most noticeable faculæ are designated α , β , γ , and δ . The chief spot (A) consisted of several umbræ contained in, or surrounded by, one penumbra; and it will be seen that prolongations of this penumbra extended to some, otherwise isolated, minute spots, at some little distance from the main mass. Spot B was of a long oval form, and a curious (dark) break was perceptible, dividing the umbra into two portions; and spot C consisted of two separate ones, surrounded by a single penumbra. The two small groups, *a* and *b*, scarcely demand any notice. With reference to the faculæ, that marked α in the key-map was situated at an angle of about 64° from the true north point measuring (as in the ordinary position-micrometer) towards east. It was double, and consisted of two nearly parallel *f* form streaks of light; the smaller, or following, one of which was inclined at its higher, or southern part, towards the larger was a very confused group of faculæ (with maculæ intermixed) just being brought on to the sun's disk by his rotation; it

a position-angle of about 115° . Proceeding onwards, we arrive at γ , another double facula, with a distant resemblance to α . In this case the preceding streak inclined towards the other in a sharp curve; they were about 246° from the north point. Finally, δ , at an angle of 289° , reminded me forcibly of a "Prince Rupert's drop" in its form: it was quite isolated. I may add that I took great pains with the drawing and mapping of the various physical details on account of their possible connexion (that of the faculæ especially) with the "red flames," and trust that the result may be comparable with the observations of those in Spain who witnessed these remarkable appearances, and determined their apparent position on the solar limb.

The Eclipse.—The moment of first contact was, I believe, at $9^h 26^m 55^s$ L.S.T. = $1^h 40^m 45^s$ L.M.T. The moon's advancing limb was exceedingly rugged, four high mountains being very conspicuous. It is a curious fact that the moon appeared to have the effect of stilling the undulations of the solar limb at the points where she cut it. At $9^h 43^m 23^s$ L.S.T. = $1^h 57^m 0^s.3$ L.M.T. the moon's limb centrally covered the group lettered A, and soon afterwards the advance of our satellite disclosed a regular sierra of mountains to the south of those already seen. At $2^h 6^m$ L.M.T. I turned the telescope on *Venus*, who was then about 11 hours from her inferior conjunction. She presented an exquisitely beautiful appearance, and her brilliancy was considerably heightened by the relative darkness which prevailed. I send a drawing of the appearance which she exhibited: albeit it is difficult to convey her extreme apparent tenuity faithfully. To return to the sun:—At $10^h 24^m 18^s$ L.S.T. = $2^h 37^m 48^s.6$ L.M.T. the moon's limb was centrally over spot B, whence it steadily advanced and covered spot C centrally at $10^h 32^m 33^s$ L.S.T. = $2^h 46^m 2^s.2$ L.M.T.; not the slightest change was remarked in the aspect of the maculæ, as the moon approached them, both umbræ and penumbæ remaining perfectly sharp and crisp up to the lunar limb. For some time after this the effect of the sunlight, as seen with the naked eye, was very remarkable. A dimness and dullness of a lurid tint seemed to overspread the landscape. Something of the sort might have been produced by a dense veil of mist covering the sun, but the continuation of sunshine and the sharpness of the shadows thrown by posts, rails, and trees, at once must have shown, even to a person ignorant of the eclipse, that this curious diminution of light had no reference to any merely atmospheric cause. The effect of comparative darkness was considerably more striking than on the occasion of the larger eclipse of March 15th, 1858; as, on that day, the dense, impenetrable nimbi only conspired with the obscured sun to give the effect of a dull summer evening; whereas, on the present occasion, this odd unearthly light was coexistent with apparently full sunshine. I may add that a curious and instructive effect of irradiation was presented at

this time, when any temporary passing cloud enabled the observer to regard the sun with the naked eye, or with a pale tinted glass. Under such circumstances, the moon's limb appeared to cut off scarcely one-third of the solar disk; and it was only on reference to the telescope, or on the employment of a glass sufficiently darkened, that the illusion was dispelled, and it was seen that in reality the sun was more than two-thirds obscured. At $10^h 4^m 8^s.3$ L.S.T. = $3^h 1^m 29^s.7$ L.M.T. spot A was again centrally uncovered; and at $11^h 15^m 11^s$ L.S.T. = $3^h 28^m 33^s.2$ L.M.T. the lunar limb was just half off spot C. After this, the clouds which had more or less been scattered over the heavens all day, began to close rapidly over the sun, and, consequently, the emergence of spot B, and the moment of last contact of the limbs of the sun and moon, were invisible. I made a despairing effort to observe the last contact with the whole telescopic aperture, and an eye-piece undefended even by a dark glass, but in vain, the clouds were impenetrable! I observed, as usual, with my Ross equatoreal of 4.2 inches aperture. The map was made with an eye-piece magnifying 115 times and wired in squares of 1' each. The eclipse was viewed with a power of 74, and throughout the whole aperture of the telescope was employed, and a piece of smoked talc placed within the focus of the object-glass; an arrangement which I find affords an exquisite view of the details of the solar disk, and which obviates the necessity for diminishing the area of the object-glass by diaphragms.



Key to Map of the Sun, July 18, 1860.

(at 1 hour G.M.T.)

A, large Spot (or group in one penumbra) preceding. B and C smaller spots following. α , minute group of spots nearly S of A. δ , minute group of spots S P C. α , double facula at a position angle of 64° . β , group of faculae (with maculae intermixed, just coming on to the sun's disk) at an angle of 115° . γ , another double facula at 246° . δ a facula in the form of a "Prince Rupert's drop," at an angle of 289° . The angles are measured from the north point round by the E, S & W, as in the common position micrometer and are subject to a probable error of $\pm 1^\circ$.

Observed at Uckfield, Sussex, by C. Leeson Prince, Esq.

On the morning of July 18th, 1860, the sky was densely overcast, and some heavy showers fell at intervals before 9 A.M. At 10 A.M. the sky still remained obscured, and it was not until about 10^h 40^m that a patch of blue sky becoming visible over the Downs, gave some hope that a glimpse of the eclipse might, perhaps, be obtained. At 11^h 30^m the sky was about half covered by cloud. At noon the whole of the southern sky was almost free from cloud, and, with the exception of an occasional broken cumulus passing before the sun, the sky remained clear till a little past 3 P.M.

The major portion of the phenomenon was seen to great advantage in this latitude. The atmosphere was found to be remarkably diaphanous, and not the slightest tremor could be observed upon the edge of the solar disk. The faculæ and spots were seen beautifully defined.

As a prelude to any notes of the time of contact, I will remark that my observatory is situated 200 feet above the level of the sea, in latitude 50° 58' 25" North, and in longitude 0^h 0^m 24^s.3 East. My equatorial telescope has an aperture of 6.8 inches, and a focal length of 12 feet.

By applying a Dawes eye-piece to a power of 140, I was enabled to use very satisfactorily the whole aperture of the object-glass. The first contact happened exactly at 9^h 27^m 6^s local sidereal time; and I almost immediately observed two remarkable lunar peaks enter upon the sun's disk, and as nearly as possible at the point of contact.

The following notes of time I took with great care:—

	Large Spot.	Spot West of two.	Spot East of two.
	Local Sid. Time.	Local Sid. Time.	Local Sid. Time.
	h m s	h m s	h m s
First contact with Penumbra	9 41 47	10 23 53	10 31 52
„ with Spot	9 43 3	10 24 14	10 32 14
Spot occulted	9 43 46	10 24 40	10 33 4
Penumbra occulted	9 44 31	10 24 54	10 33 19

At the time of greatest obscuration the horns of the crescent were particularly sharp and well defined, without the least sign of distortion which could be attributed to a supposed lunar atmosphere. The diminution of light was very considerable, and objects at a short distance appeared enveloped in a grayish blue haze, somewhat similar to the peculiar hue cast upon the landscape on a hot summer day, just after the sun has been obscured by a dense mass of cumulo-stratus cloud threatening a hasty shower. Soon after 3 P.M. clouds gradually came up from the south-west, and from 3^h 30^m the sun was entirely obscured during the remainder of the eclipse. I imagined that the last contact could not have been seen in this county.

Uckfield, Sussex, Oct. 20, 1860.

Observed at Highbury, by T. W. Burr, Esq.

Being unable to leave England at the time of the Eclipse, I made such observations of the attendant phenomena as the weather permitted. The morning was exceedingly unfavourable, but about noon considerable improvement took place, the sun being visible, though the sky still remained cloudy. From one o'clock to half-past it was very fine, but as the time for the commencement of the eclipse approached the clouds closed and the first contact was lost, the sun not being seen again till $1^h 49^m 31^s$, G.M.T., when the moon had made some progress on its disk. I had intended making a careful diagram from measures of the sun's appearance before the eclipse, upon which its successive phases could have been indicated; but there was no opportunity for doing this work. There were three conspicuous spots, or rather clusters, on the sun's face; one, the largest and most complex, near the south-east limb (as seen in the inverting telescope), and the other two near the north-west and west parts of the disk. Having failed to catch the first impression of the moon's limb on the sun, the next thing was to obtain as many time-observations of the passage over the spots as possible; and the contact of the moon with the penumbra of the first and largest cluster of spots took place at $1^h 54^m 10^s.6$ G.M.T. At $1^h 55^m 30^s.3$ the largest nucleus of this mass was reached, and by $1^h 56^m 20^s$ the whole of the nuclei in this cluster were covered. The disk being now clear for a considerable space, attention was directed to the appearance of the moon's limb, which was distinctly seen to be very rough and serrated; while both it and the sun's edge were in a state of great undulation, and it was perfectly obvious that had the two disks been concentric, the uneven edge of the moon, with its prominences and depressions exaggerated by the "boiling" and irradiation, would almost certainly have produced the effect of rendering "Baily's beads" visible at the two points of contact. I was also particularly struck at this time ($2^h 25^m$) by seeing a portion of the moon visible beyond the part where it was projected on the sun. This was evident at both places where it cut the disk, but more particularly at the upper cusp. The moon's body was visible for about $4'$ from the sun's border, and was seen, not by any light proceeding from it, but by its intense blackness as compared with the sky background. The impression on the eye was not a transient one, but was seen, whenever the eclipse was visible, for half an hour from this time. At $2^h 35^m 51^s.5$ the penumbra of the second spot was reached, and by $2^h 36^m 43^s$ the spot and penumbra were covered. Dense clouds then covered the heavens until after the greatest obscuration, and nothing could be noted but the terrestrial appearances. These were sufficiently striking:—a gradual gloom had come over the scenery, the clouds having a lurid character similar to an impending thun-

derstorm ; they were very dark, and seemed lower than usual ; in fact, they gave the impression of a rapid descent on the earth. The wind blew strongly from the south-west, and produced an unpleasant and unusual chilliness. Near the zenith a few breaks showed the sky of a deep indigo hue, while towards the horizon, which was very indistinct, the clouds had a copper-coloured tinge. Birds appeared to be returning to the trees from their excursions, and were noticeably silent during the greatest gloom. By 3^h 5^m most of these peculiar effects were gone ; the clouds had become light and silvery, the sky between them pale blue, and the wind lowered. The passage of the obscurity from the north-west to the south-east could also be distinctly traced. The temperature now began to rise from the depression it had suffered. During the brightest part of the morning, about 1^h 30^m, the thermometer had reached 71°·5 ; it fell gradually during the eclipse to 2^h 50^m, when it stood at 61°·5, and afterwards recovered the elevation of 65° by four o'clock, when the eclipse was over. The passage of the moon again became visible, and at 2^h 58^m 29^s·9 a very small spot, below the large one, was uncovered. In another minute the nucleus of the large spot began to emerge, and by 3^h 0^m 19^s was quite clear. At 3^h 0^m 54^s·4 the penumbra of this cluster was entirely visible. Clouds again intervened, and when they had passed, the second spot was clear ; and at 3^h 42^m 52^s·5 the nucleus of the third spot appeared. I was very desirous of getting an observation of the time of the last contact, but the clouds deprived me of it. I saw the moon still projected on the sun at 3^h 52^m 38^s·9, and evidently within a few seconds of leaving it ; but a cloud once more covered them, and when the sun reappeared at 3^h 54^m 25^s, the eclipse had passed. My observations were made throughout with my usual instrument, the equatoreal by Ross, of 3 $\frac{1}{2}$ inches aperture, at first with direct vision and a power of 58 ; but after the largest spot was passed, a Hodgson reflector was used, with a power of 100. The latitude and longitude of my observatory are 51° 33' 42"·1 N. and 23°·9 W.

August 1860.

Observed at Haddenham, Bucks, by the Rev. W. R. Dawes.

The solar eclipse of July 18 was observed here under remarkably favourable circumstances until the greatest obscuration was past, when the thin and detached clouds, which had prevailed during the earlier part of the afternoon, thickened so much as completely to obscure the termination of the eclipse.

The first impression on the sun's edge was made by the highest part, near the southern extremity, of the remarkable chain of hills on the moon's eastern limb, named "The D'Alembert Mountains" in the Rev. T. W. Webb's excellent index

map, in his very useful little work entitled *Celestial Objects for Common Telescopes*. During nearly the whole time that the eclipse was visible the image was unusually tranquil, and so distinct, even through the thin stratum of cloud which often covered it, that on my $8\frac{1}{4}$ -inch object-glass powers of from 145 to about 520 were employed with excellent effect. The most minute and delicate feathery portions of the penumbra of the large spot in the sun's north-western quadrant were thus brought out with admirable distinctness, and their occultation by the moon's sharply defined edge was most carefully watched. Neither on these, nor on the darker part, (or *umbra*,) of the spot, was the slightest effect produced, either in form or shade, previous to their disappearance.

The moon's limb, just off the disk of the sun and close to it, was repeatedly examined by placing portions of it in a small field of my solar eye-piece, from which the sun was excluded, and using as light a shade as my eye could comfortably bear. No light on any part of the moon's edge could be even suspected.

About the time of the greatest obscuration a very thin cloud near the sun to the south displayed extraordinarily vivid prismatic colours, through a part of which the planet *Venus*, then very nearly at her inferior conjunction, appeared of a delicate pink. This planet was visible through the cloud when the aperture of the finder was reduced to half an inch; and in a clear sky, with an aperture of only $0^{\text{m}}.36$, she looked like a semicircular nebula. Her distance from the sun's southern limb was about 5° .

Haddenham, Thame, Nov. 1860.

Communications were also received from —

Mr. F. Morton, at the Wrottesley Observatory. On account of the unfavourable state of the weather the first contact could not be seen, but the last contact was observed to take place at $3^{\text{h}} 41^{\text{m}} 56^{\text{s}}$, Wrottesley mean time; but as it was seen through the edge of a cloud the time is considered as uncertain to the extent of about one second.

John M. Stodhart, at Dublin; the morning was so cloudy that all idea of telescopic observations was abandoned, and the only observations obtained were of the barometer and thermometer.

C. B. Chalmers, Shanty Bay, County of Simcoe, Canada West. The first and last contacts are stated to have been well observed, and the occultations and emergences of several spots were also observed, but the times were obtained to minutes only

The Society has been favoured with a communication from Thomas Frazer, Esq., Secretary of the Hudson's Bay Company, enclosing Reports of Observations of the Eclipse, made by several of the officers of the Company, J. Mackenzie, at Moose Factory, Chief Trader R. Hamilton, at Great Whale River; Chief Trader J. R. Clare, at York Factory; J. P. Gardiner, at Churchill; and Will. Simpson, at Fort Churchill. But the want of instruments and the general unfavourable state of the weather were impediments in the way of any precise observations.

Papers were also received from the Astronomer Royal for Scotland and from Mr. Carrington, containing the determination of the positions of the principal spots near the circumference of the sun's disk, as well on the visible as the invisible hemisphere, at the time of the eclipse.

Results of Meridional Observations of Small Planets and Occultations of Stars by the Moon, observed at the Royal Observatory, Greenwich, from June to October 1860.

(Communicated by the Astronomer Royal.)

Metis (9).

	Mean Solar Time of Observation.			Apparent R. A.			Apparent N. P. D.		
	h	m	s	h	m	s	°	'	"
1860, Aug. 16	12	5	4.0	21	47	26.76			
22	11	35	32.4	21	41	29.68	113	34	7.38
27	11	11	5.0	21	36	41.06	113	55	17.52
31	10	51	43.8	21	33	2.84	114	8	51.50
Sept. 1	10	46	55.3	21	32	10.14	114	11	50.14
11	10	0	2.0	21	24	34.66	114	30	29.09
12	9	55	28.8	21	23	57.23	114	31	10.21
19	9	24	21.4	21	20	20.66	114	31	1.77
Oct. 2	8	30	31.8	21	17	37.32	114	7	49.83
4	8	22	42.9	21	17	40.29	114	1	53.55
8	8	7	27.2	21	18	8.25	113	48	10.93
11	7	56	19.1	21	18	48.07	113	36	26.52
17	7	34	50.3	21	20	55.03	113	9	22.71
20	7	24	28.2	21	22	20.85	112	54	15.85
26	7	4	26.3	21	25	55.04	112	20	46.75
29	6	54	45.2	21	28	2.00	112	2	40.64
30	6	51	34.1	21	28	46.89	111	56	27.49

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Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
	h m s	° ' "
1860, Oct. 20	13 57 19.9	3 56 17.11
		80 35 22.96

Irene (14).

Mean Solar Time of Observation.			Apparent R.A.			Apparent N.P.D.		
	^h	^m ^s	^h	^m ^s	[°] ['] ^{''}			
1860, Aug. 16	11	38 2.9	21	20 21.22	117 0 41.79			
17	11	33 12.6	21	19 26.74	117 5 16.03			
22	11	9 8.1	21	15 1.06	117 26 1.34			
Sept. 6	9	59 8.8	21	3 58.53	118 2 30.63			
12	9	32 27.4	21	0 52.08	118 6 24.64			
Oct. 4	8	2 33.7	20	57 27.78	117 35 29.23			

Eunomia (15).

Mean Solar Time of Observation.			Apparent R.A.			Apparent N.P.D.			
	h	m	s	h	m	s	°	'	"
1860, Aug. 16	12	8	54.7	21	51	18.13	90	50	56.07
17	12	4	0.0	21	50	19.11	90	50	5.29
22	11	39	24.4	21	45	22.31	90	47	38.64
27	11	14	53.7	21	40	30.36	90	48	16.78
29	11	5	10.9	21	38	39.04	90	49	18.67
30	11	0	17.6	21	37	41.54	90	49	59.32
31	10	55	27.2	21	36	46.83	90	50	44.17
Sept. 1	10	50	37.4	21	35	52.84	90	51	39.29
10	10	7	58.7	21	28	36.09	91	2	16.21
11	10	3	20.9	21	27	54.10	91	3	39.61
12	9	58	44.7	21	27	13.68	91	5	10.89
13	9	54	10.0	21	26	34.75	91	6	38.71
14	9	49	36.7	21	25	57.30	91	8	13.04
19	9	27	16.2	21	23	15.91	91	15	55.59
Oct. 2	8	32	45.2	21	19	51.16	91	33	13.28
3	8	28	46.9	21	19	48.76	91	34	11.67
5	8	20	55.9	21	19	49.55	91	35	57.52
8	8	9	23.5	21	20	4.93	91	38	4.51
9	8	5	36.7	21	20	14.04	91	38	40.29
11	7	58	8.3	21	20	37.52	91	39	26.95
20	7	26	0.4	21	23	53.32	91	38	33.54
22	7	19	8.3	21	24	53.20	91	37	10.11
26	7	5	52.4	21	27	21.37	91	33	8.50

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Fortuna (19).

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ' "
1860, Oct. 20 13 12 55.2	3 11 45.12	72 34 8.34

Calliope (23).

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ' "
1860, June 14 10 54 46.3	16 28 34.41	114 24 47.10

Euterpe (37).

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ' "
1860, Oct. 3 12 8 43.6	1 0 21.55	86 41 44.15
16 11 5 22.6	0 48 5.37	87 55 51.12
17 11 0 32.4	0 47 10.88	88 1 3.44
18 10 55 42.6	0 46 16.87	88 6 10.62
20 10 46 5.6	0 44 31.43	88 15 58.44

Bellona (38).

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ' "
1860, Aug. 17 9 48 13.3	19 34 10.12	106 39 34.93
Sept. 19 7 32 24.2	19 28 5.04	108 32 7.55

Amphitrite (39).

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ' "
1860, Oct. 20 13 29 22.7	3 28 15.30	63 22 28.19
29 12 46 17.7	3 20 32.28	63 17 7.05

Harmonia (40).

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ' "
1860, July 20 10 20 5.4	18 15 43.94	114 50 3.39

Isis (49).

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ' "
1860, July 6 11 52 16.5	18 52 58.39	118 45 57.04
14 11 13 17.1	18 45 25.04	119 47 29.36
Aug. 17 8 45 56.4	18 31 42.99	122 11 48.26

Europa (52).

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ' "
1860, Aug. 4 11 8 19.3	20 3 14.11	109 8 24.99

*Elements of Planet (59).**Planet (59).*

Mean Solar Time of Observation.			Apparent R.A.			Apparent N.P.D.		
	^h	^m	^s	^h	^m	^s	[°]	[']
1860, Sept. 18	12	43	16.8	0	35	52.15	89	44 35.45
19	12	38	41.2	0	35	12.32	89	53 44.98
25	12	10	54.9	0	31	0.78	90	49 15.43
Oct. 3	11	33	41.1	0	25	13.32	92	2 4.09
16	11	33	58.2	0	16	35.80	93	46 0.28
17	10	29	28.3	0	16	1.69	93	52 50.96

All the observations of N.P.D. have been corrected for parallax.

Occultations of Stars by the Moon.

Day of Obs.	Phenomenon.	Moon's Limb.	Mean Solar	Observer.
			Time.	
1860, Sept. 6	27 Tauri, disapp.	Bright	^h 12 ^m 32 ^s 19.6	C.
6	27 Tauri, disapp.	Bright	12 32 12.8 (a)	J. C.
6	28 Tauri, disapp.	Bright	12 34 40.0	E.
6	7 Tauri, reapp.	Dark	12 49 41.0	E.
6	7 Tauri, reapp.	Dark	12 49 40.4	J. C.
6	27 Tauri, reapp.	Dark	13 37 24.3	E.
6	27 Tauri, reapp.	Dark	13 37 25.5	J. C.
6	28 Tauri, reapp.	Dark	13 43 40.7	E.
6	28 Tauri, reapp.	Dark	13 43 40.2	J. C.

(a), Uncertain to about half a second.

The initials E. and J. C. are those of Mr. Ellis and Mr. Carpenter.

Elements of Planet (59), determined from the meridian observations made with the Transit Circle at the Royal Observatory, Greenwich, on Sept. 18, Oct. 3, and Oct. 16. By Mr. W. Ellis, Assistant at the Royal Observatory, Greenwich.

Mean Anomaly	350° 56' 49.2	1860, Oct. 2, 12 ^h G.M.S.T.
Long. of Perih.	18 55 46.7	} Mean Equinox 1860.0
„ Asc. Node	170 18 17.0	
Inclination	8 36 30.5	
φ	6 49 30.6	
Log a	0.4336174	
μ	793'' 561	

Approximate Ephemeris, calculated from the Elements above.

For Greenwich Mean Noon.

1860.	Apparent R.A.	Apparent N.P.D.	Log. Δ
	^h ^m ^s	[°] [']	
Nov. 5	0 9 18	95 20'2	0'1973
6	9 10	95 22'6	
7	9 4	95 24'8	
8	9 0	95 26'8	
9	8 57	95 28'5	0'2072
10	8 56	95 30'0	
11	8 56	95 31'2	
12	8 58	95 32'2	
13	9 2	95 33'0	0'2175
14	9 7	95 33'6	
15	9 14	95 34'0	
16	9 22	95 34'1	
17	9 32	95 34'0	0'2281
18	9 43	95 33'6	
19	9 56	95 33'1	
20	10 11	95 32'4	
21	10 27	95 31'4	0'2390
22	10 44	95 30'2	
23	11 3	95 28'9	
24	11 24	95 27'3	
25	11 46	95 25'5	0'2501
26	12 9	95 23'5	
27	12 34	95 21'4	
28	13 1	95 19'1	
29	13 28	95 16'5	0'2613
30	13 58	95 13'8	
Dec. 1	14 28	95 10'9	
2	15 0	95 7'8	
3	15 33	95 4'5	0'2724
4	16 7	95 1'1	
5	16 43	94 57'5	
6	17 20	94 53'8	
7	17 59	94 49'8	0'2835
8	18 38	94 45'7	
9	19 19	94 41'4	
10	20 1	94 37'0	
11	20 45	94 32'6	0'2945
12	21 29	94 27'9	
13	22 15	94 23'0	
14	23 2	94 18'0	

34 *Mr. Pogson, Magnitude Constants for Minor Planets.*

ing to any good average telescope is sufficiently defined by the formula:—

$$\text{Limit of Vision} = 9.2 \text{ mag.} + 5 \text{ times log. aperture in inches.}$$

The magnitude of any planet, whose mean distance from the sun is denoted by a , and its actual distances from the sun and earth, as usual, by r and Δ , becomes known by the expression:

$$\text{Magnitude} = M - 5 \log (a^2 - a) + 5 (\log r + \log \Delta)$$

or putting N for the first two terms:—

$$\text{Magnitude} = N + 5 (\log r + \log \Delta)$$

The constant M is the mean opposition magnitude; i.e. the brilliancy of any planet, if, when in opposition, it and the earth were at their respective mean distances from the sun. The number N is the magnitude such planet would acquire, supposing it, the sun and the earth, to be situated at the three angles of an equilateral triangle, the sides of which equal the earth's mean distance from the sun. The number of estimations upon which these light constants depend is added, and although at least twenty of each will be obtained before *final* values are adopted, there is seldom much risk of great error after four or five nights' careful records have been secured.

The utility of the magnitude ephemeris itself, as a means of saving time and trouble to planetary observers, cannot be too plainly illustrated, and I therefore beg leave to offer two very familiar examples to the notice of the Society. Agreeably to my own experience, I consider that a star or planet, to be satisfactorily observable with a ring or other dark field micrometer, must be at least three-fourths of a magnitude brighter than the limit of vision of the telescope; but that with spider lines, and the smallest amount of requisite illumination, it will be *impossible*, under ordinary conditions, to observe an object less than two entire magnitudes within or brighter than the limit. Thus, on the photometric scale adopted, 12.2 magnitude being the limit of vision for a four-inch aperture, the faintest planet observable with illumination will be a trifle below the tenth magnitude; or, with a ring-micrometer and dark field, will be of the 11.5 magnitude. For the great transit circle of the Royal Observatory, eight inches in aperture, the limit of vision being 13.7 magnitude, planets under the 11.5 magnitude cannot well be observed with illumination; though disappearances behind thick bars might, with difficulty, be noted almost to the thirteenth magnitude.

When the predicted magnitude of a faint planet is brighter than its mean opposition magnitude, it should be well followed up. Thus; *Euphrosyne*, *Atalanta*, *Hestia*, and *Virginia*, may be easily recognised at their next oppositions; while *Polyhymnia*

and *Circe* may be despaired of, except with monster equatorials and dark field micrometers.

The ephemeris for 1861, based upon the following constants, will be found upon pages 71 and 72 of the Supplement to the *Nautical Almanac* for the year 1864, just issued by Mr. Hind.

Planet.	M.	N.	Obs.	Planet.	M.	N.	Obs.
(1) Ceres	7.7	4.3	14	(31) Euphrosyne	11.6	7.4	4
(2) Pallas	8.0	4.5	16	(32) Pomona	10.7	7.6	7
(3) Juno	8.5	5.3	3	(33) Polyhymnia	11.6	8.0	12
(4) Vesta	6.6	4.1	10	(34) Circe	11.7	8.5	6
(5) Astrea	10.0	6.9	19	(35) Leucothea	12.2	8.3	11
(6) Hebe	8.6	5.9	24	(36) Atalanta	12.9	9.5	5
(7) Iris	8.6	6.0	33	(37) Fides	10.5	7.4	11
(8) Flora	8.9	6.8	22	(38) Leda	11.1	7.8	9
(9) Metis	8.9	6.3	15	(39) Letitia	9.4	6.0	6
(10) Hygeia	9.8	5.6	13	(40) Harmonia	9.1	6.8	14
(11) Parthenope	9.5	6.7	20	(41) Daphne	10.2	7.6	1
(12) Victoria	9.6	7.2	12	(42) Isis	10.5	7.8	18
(13) Egeria	9.9	6.8	12	(43) Ariadne	10.2	8.1	12
(14) Irene	9.7	6.6	15	(44) Nysa	10.3	7.6	7
(15) Eunomia	9.1	5.9	17	(45) Eugenia	10.8	7.5	7
(16) Psyche	10.1	6.3	12	(46) Hestia	11.6	8.6	9
(17) Thetis	10.0	7.2	10	(47) Aglaia	11.2	7.5	9
(18) Melpomene	9.5	7.1	18	(48) Doris	11.0	6.9	7
(19) Fortuna	9.7	6.9	16	(49) Pales	10.8	6.8	13
(20) Massilia	9.3	6.6	14	(50) Virginia	11.9	8.7	5
(21) Lutetia	10.5	7.7	13	(51) Nemausa	10.4	7.9	6
(22) Calliope	10.0	6.3	9	(52) Europa	10.5	6.4	19
(23) Thalia	10.5	7.4	10	(53) Calypso	11.5	8.4	3
(24) Themis	11.0	6.8	5	(54) Alexandra	11.0	7.7	5
(25) Phoebe	10.6	8.0	5	(55) Pandora	10.9	7.5	13
(26) Proserpine	10.7	7.5	12	(56) Pseu. Daph.	11.5	8.4	1
(27) Euterpe	9.7	7.2	8	(57) Mnemosyne	10.9	6.8	7
(28) Bellona	10.1	6.7	6				
(29) Amphitrite	9.1	6.1	34				
(30) Urania	10.0	7.5	14				

Hartwell Observatory, Nov. 8, 1860.

On a Photograph of the Sun, taken with the Northumberland Telescope of the Cambridge Observatory. By Professor Challis.

In making the following photographic experiment I was favoured, through the kindness of a friend, with the valuable assistance of Mr. Hardwick, to whose skilful preparation of the collodion sensitized plates, and processes of development, the success of the experiment is mainly to be attributed. For the support of the photographic apparatus a frame, made for lightness of deal and covered with blackened canvass, was prepared, so that it could be readily and firmly attached to the eye-end of the telescope. The form of the frame was in part cylindrical, and in part that of a frustum of a four-sided pyramid, the smaller end of which was provided with grooves for holding the plates. The proper position of the eye-piece was ascertained by adjusting it so as to cast an image of the sun on a sheet of paper put in the place prepared for the sensitized plate; but no attempt was made to allow for the difference of the focal lengths of the telescope for the chemical and luminous rays, which in this mode of experimenting appears to have little effect. The remaining operations were extemporised after Mr. Hardwick's arrival at the observatory on July 28, on which day from 2^h to 3^h the experiments were made. In the first instance the whole aperture of the object-glass, the diameter of which is $11\frac{1}{2}$ inches, was tried; but the sun's action being found to be far too strong the aperture was greatly reduced, till the diameter finally fixed upon was not more than $1\frac{1}{4}$ in. As no means had been provided for admitting and stopping the sun's rays at the eye-end of the telescope, without causing an injurious amount of tremor, an opaque screen was mounted on a pole and held at a small distance from the object-glass, and on a signal being given, when the plate was in place, the screen was passed and returned so as to expose the aperture to the solar rays as brief an interval as was possible with this mode of operating. It would have been better to have simply moved a slit in the screen across the aperture; for, although the aperture was so much reduced, the sun's action was still too strong.

The focal length of the Northumberland telescope being $19\frac{1}{2}$ ft., the diameter of the image of the sun's disk formed at the focus on the day of the experiment was 2.15 in. The magnifying power of the eye-piece was 100, and the distance of the photographic plate from the focus of the object-glass about 13 inches. By the reduction of the effective aperture the brightness of the focal image was diminished in the ratio of the square of $11\frac{1}{2}$ to the square of $1\frac{1}{4}$, that is, in the ratio of 78 to 1. And as the diameter of the image thrown on the plate was found by measurement to be 11.42 in., the ratio of the brightness of this image to that of the focal image was equal to the square of the ratio of 2.15 to 11.42, that is, to the ratio of 1 to 28

nearly. Although the brightness of the final image was thus made less than that of the focal image formed by the whole aperture of the object-glass, in the ratio of 1 to 2200 nearly, the sun's action during a very small fraction of a second sufficed to produce a very decided impression.

The photographic picture resulting from the experiment (a specimen of which accompanies this note) exhibits a portion of the sun's disk, limited by the boundary of the field of view and by an arc of 43° of the limb, and containing two groups of spots of moderate size. The contrast between the dark nucleus and its surrounding penumbra, and the definite exterior boundary of the latter, are well expressed. About the group which is nearest the limb, the *faculae* which generally accompany groups in this position are distinctly visible. Also the diminution of the brightness of the sun's disk towards the periphery, which is now an admitted fact, is very manifest in the photograph.

During the experiment the equatoreal was carried by clock-movement. When, however, the time of exposure is as brief as it was in this instance, this movement, which necessarily produces some amount of tremor, may probably with advantage be dispensed with. If at the same time the sun's rays be admitted at the object-glass in the manner above described, instrumental tremor will be completely avoided. The method of admitting the light by suddenly letting fall a diaphragm connected with the telescope is faulty in principle, because the breaking of the connexion is mechanically equivalent to giving an impulse to the telescope. Also if the diaphragm be let fall at the eye-end of the telescope, the light which passes through the slit must, as it crosses the field, be accompanied with diffraction light; whereas if the light be admitted at the object-glass, there is no diffraction light except at the boundary of the field, where it is of no consequence. It is known, from the principles of optics, that in the latter arrangement the *whole* of the image within the field of view is illumined, so long as the sun's rays are not entirely cut off by the diaphragm, and consequently that the illumination advances gradually from zero to a maximum, and passes off as gradually. These would appear to be conditions very favourable to the production of good definition.

Cambridge Observatory, Nov. 8, 1860.

Développement de la Fonction Perturbatrice en Série.

Par M. Kowalski. (Abstract.)

If v, v' are the true anomalies, ω, ω' the distances of the pericentres from the mutual node, and if

$$\begin{aligned} v - v' + \omega - \omega' &= \theta \\ v + v' + \omega + \omega' &= \psi, \end{aligned}$$

then the reciprocal of the distance of the two planets can be developed in the form

$$\frac{1}{\zeta} = \frac{1}{2} \sum_i Z_i^\beta \cos(i\theta + \beta\psi),$$

where i and β extend from $-\infty$ to ∞ and $Z_i^{-\beta} = Z_i^\beta$.

Moreover, if z, z' denote the mean anomalies, and if the general term of the development of $\frac{1}{\zeta}$ is represented by

$$X \cos(\pi z - i z' + \eta u - \eta' u'),$$

where X can be expressed as a definite integral involving the coefficient Z ; viz. the general term of X is

$$= \frac{1}{\pi^2} \int_0^\pi \int_0^\pi Z_{i+\eta}^\beta \cos(\pi z - \eta v) \cos(i z' - \eta' v') dz dz',$$

and the value of the coefficient X is obtained by means of a series of transformations effected upon this definite integral. The memoir has been published in the *Récherches Astronomiques de l'Observatoire de Kasan*, 1859.

Minor Planets (80), (81), (92).

Since the discovery by M. Chacornac of Minor Planet (80), three new Minor Planets have been discovered. As referred to by M. Leverrier (*Comptes Rendus*, 16th Oct. 1860), these are:—

Minor Planet (80), discovered by Mr. Ferguson, at Washington, on the night of the 15th Sept. The observed place was approximately,

	Washington M.T.	R.A.	N.P.D.
1860, Sept. 15	10 ^h 22 ^m 5 ^s	23 ^h 4 ^m 30 ^s .4	93° 23' 39"

Daily motion — 54°.0 in Right Ascension and 9°.0 in North Polar Distance. It was noted on the night of the 14th as one not on Chacornac's Charts; and on the 15th its planetary character became evident. Estimated magnitude 11.

Minor Planet (81), discovered by M. Goldschmidt on the 9th Sept., and recognised as a Planet on the 19th. See last Number of the *Monthly Notices*, where this Planet is referred to as Minor Planet (80). The name *Danaë* has been given to it.

Minor Planet (92), discovered at Berlin by Dr. Forster and M. Lesser. First observed the 14th Sept., but supposed to be M. Chacornac's Planet (80). The continuation of the observations up to the 10th Oct. showed that the Planet was really a distinct one. Estimated magnitude 11. Elements calculated

by MM. Romberg and Tietjen, from the Berlin Observations of the 14th and 24th Sept. and 8th Oct. 1860, (see *Ast. Nach.* No. 1281, where there is also given a slightly different set of elements calculated by Dr. Seeling of the Glasgow Observatory).

Epoch, 1860, Sept. 24, 5 ^h 16 ^m 84 ^s .			
Mean longitude	334	55	19
Excentricity	9	25	52
Longitude of perihelion.....	40	11	4
Longitude of node.....	126	56	45
Inclination	2	14	15
Diurnal motion	636	320	
Log. mean distance	c.	497554	

} Mean Equinox
of 1860^o.

The name *Erato* has been given to this planet.

Discovery of a New Comet.

In Leverrier's *Bulletins* of the 25th and 26th Oct. is contained the intelligence of the discovery of a new comet by M. Tempel at Marscilles. The following approximate place is given by M. Villarceau in the *Bulletin* of the 26th Oct.

			R.A.	Decl.
	^h	^m	^h ^m ^s	^o [']
Oct. 25	15	30	Paris 10 5 18	+ 31 26

MISCELLANEOUS INTELLIGENCE.

Mr. Norman Robert Pogson has been appointed Astronomer at the Madras Presidency.

Sir John Herschel has forwarded to one of the Secretaries a letter from Prof. Erman, of Berlin, which he desires to bring before the notice of the Society. The following is the substance of the letter in question:—

“The Prussian Government contemplate erecting a bust of Bessel on the outside of the University-buildings at Königsberg, where it will range with those of other celebrities. The sculptor, Herr Siemering, who has prepared the bust from existing representations of Bessel, wishes to obtain orders for a copy or copies of his work, which is suited for erection in a public place, and is regarded by Prof. Erman as a faithful likeness. At his request, Prof. Erman has forwarded a photograph taken from the original to Sir J. Herschel, desiring

him to bring H. Siemering's proposal before English astronomers, and to say, at the same time, that copies on a reduced scale can be supplied if desired. The original bust is about double life-size. The photograph can be seen at the apartments of the Society."

Address, Herr Bildhauer Siemering, durch H. Geheim Ober-Baurath Stüber, Berlin.

To be sold :—

1. Gregorian reflecting telescope, with 6-inch speculum, on firm iron stand, with equatoreal motion, three eye-glasses ranging in power from 120 to 600.

2. Newtonian reflecting telescope, with 11-inch speculum, on firm iron stand, with two eye-glasses.

For further information, apply to the Assistant-Secretary.

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MONTHLY NOTICES
OF THE
ROYAL ASTRONOMICAL SOCIETY.

VOL. XXI.

Dec. 14, 1860.

No. 2.

The Rev. R. MAIN, President, in the Chair.

Sir Charles Tilstone Bright, 12 Upper Hyde Park Gardens,
was balloted for and duly elected a Fellow of the Society.

On a Method for determining Longitude by means of observations on the Moon's greatest Altitude. By William Spottiswoode, Esq., M.A., F.R.S., &c. (Abstract.)

The object of the present investigations is to suggest a method whereby, at certain parts of the moon's orbit, and under favourable circumstances, the longitude may be determined by means of a simple sextant observation. The method does not attain to the same degree of accuracy as some others already in use; nor can it be successfully applied except when the moon's motion in declination is considerable; and the observation, being restricted in time to the immediate vicinity of the greatest altitude, is very dependent on weather. For the traveller supplied with proper instruments, the eclipses of *Jupiter's* satellites will, doubtless, always furnish one of the best means of determining the longitude; and for one carrying only a sextant, the method of lunar distances is superior to all others; but the labour of the latter observations is such as to render them practicable only at rare intervals on a journey, while the complexity of the calculations almost precludes the possibility of obtaining satisfactory results until the data have been sent home. A method, therefore, in which both observation and calculations are simple may not be without use, either as supplementary to more elaborate processes, or as a substitute when

they are not practicable; and the following is suggested for the use of the traveller as a check to his dead reckoning, after the last of his chronometers has broken down, and when results from lunar distances are not attainable.

The method consists in determining the moon's declination at the time of the greatest altitude. This being ascertained, if the local time be known, we have merely to compare the Greenwich time, deduced from the *Nautical Almanac*, at which she has that declination; the difference in times is of course the longitude expressed in time. If, however, the local time be not known, a formula deduced from the same data, and given in the memoir, determines the hour-angle at the time of the greatest altitude. By means of this, the correction to be applied to the moon's declination at the time of observation, in order to reduce it to that on the meridian, may be calculated; and a comparison of the declinations at her meridian passage at the place and at Greenwich, with the aid of the table of differences of declination in the *Nautical Almanac*, will give the longitude.

On the Distribution of the Perihelia of the Parabolic Comets in relation to the Motion of the Solar System in Space.
By R. C. Carrington, Esq. (Abstract.)

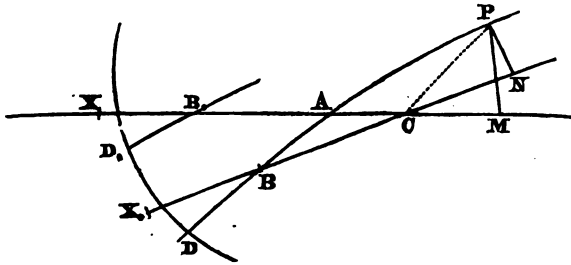
Inquiries into the direction and amount of the motion of the solar system have hitherto been entirely based upon the consideration of the residual small motions of what were once termed the fixed stars; and although the results for direction now exhibit a progressively increasing agreement and certainty, it is always desirable, where the case admits of it, to endeavour to obtain an independent result by approaching the subject from a different point of view. The bearing which the distribution of comets has on the matter was suggested by the observed horary variation in the number of meteors, and the explanation of the probable cause of this variation, given by M. Bompas in the *Monthly Notices* for Jan. 1857, by reference to the orbital motion of the earth. A like idea applies to the distribution of the parabolic comets, and the proposition stands thus:

If the comets moving in unclosed orbits be chance visitors, and if the conditions of visibility on the whole affect the discovery of all alike, it would be expected that, were the Sun at rest, the perihelia would be found equally scattered through the heavens; but if the Sun be in motion, as we now hold it to be, from α *Columbæ* to π and μ *Herculis*, then there would be found a certain excess of perihelia in the hemisphere of which

a Columba is the pole, and a certain condensation about that region, so that if for each orbit the angle were computed between *a Columba* and the comet's perihelion, the mean of these angles would be less than 90° . This is tested by the tables annexed to the memoir. It appears that out of the 133 parabolic and hyperbolic orbits considered, the perihelia of 61 lie in the hemisphere from which, and of 72 in the hemisphere to which, the sun is assumed to be moving; the mean angular distance between *a Columba* and each perihelion coming out $95^\circ 36'$, a result which superior evidence shows must be regarded as nugatory and vitiated by uncontrolled conditions, among which the principal is probably the unequal distribution of discoverers of comets in the northern and southern hemispheres of the earth.

On some Formulæ relating to the Variation of the Plane of a Planet's Orbit. By A. Cayley, Esq.

In Hansen's Memoir, "Auseinandersetzung einer zweckmässigen Methode zur Berechnung der absoluten Störungen der kleinen Planeten," Abh. der k. Sächs. Gesell. t. v. (1856), are contained, § 8, some very elegant formulæ for taking account of the variation of the plane of the orbit. These, in fact, depend upon the following geometrical theorem, viz., if (in the figure) ABC is a spherical triangle; P , a point on the side AB ; and PM , PN , the perpendiculars let fall from P on the other two sides AC , CB ; then we have



$$\begin{aligned}\cos PM \sin (BC + CM) &= \cos PN \sin BN - \tan \frac{1}{2} C \cos BC (\sin PM + \sin PN), \\ \cos PM \cos (BC + CM) &= \cos PN \cos BN + \tan \frac{1}{2} C \sin BC (\sin PM + \sin PN).\end{aligned}$$

These equations, in fact, give

$$\begin{aligned}\cos PM \sin CM &= \cos PN \sin CN - \tan \frac{1}{2} C (\sin PM + \sin PN), \\ \cos PM \cos CM &= \cos PN \cos CN;\end{aligned}$$

the latter of which is at once seen to be true, since joining the points C and P, the two sides are respectively equal to $\cos CP$. To verify the former one, write $\angle PCM = C_1$, $\angle PCN = C_2$, so that $C = C_1 - C_2$. Then, since $\cos CP = \cos PM \cos CM = \cos PN \cos CN$, $\sin PM = \sin CP \sin C_1$, $\sin PN = \sin CP \sin C_2$, the equation becomes $\cos CP (\tan CM - \tan CN) = -\tan \frac{1}{2} C \sin CP (\sin C_1 + \sin C_2)$, or since $\tan CM = \tan CP \cos C_1$, $\tan CN = \tan CP \cos C_2$, this is

$$\cos C_1 - \cos C_2 = -\tan \frac{1}{2} C (\sin C_1 + \sin C_2),$$

which is identically true, in virtue of the equation $C = C_1 - C_2$; and, conversely, we have the original two equations.

Suppose that XM is the ecliptic, X being the origin of longitudes, DP the instantaneous orbit, D the departure-point therein, and P the planet, DD₁ the orthogonal trajectory of the successive positions of the orbit; and writing

ν , the departure of the planet,
 v , the longitude of ditto,
 y , the latitude of ditto,
 ℓ , the longitude of node,
 σ , the departure of ditto,
 ϕ , the inclination;

then, in the figure, $DP = \nu$, $XM = v$, $PM = y$, $XA = \ell$, $DA = \sigma$, $\angle A = \phi$.

The quantities ℓ , σ , ϕ , might be considered as altogether arbitrary; but to fix the ideas it is better to assume at once that they denote

ℓ_0 , the longitude of node,
 σ_0 , the departure,
 ϕ_0 , the inclination,

for the initial position of the orbit, viz., in the figure $XB_0 = \ell_0$, $D_0B_0 = \sigma_0$, $\angle B_0 = \phi_0$.

Take $DB = \sigma$, $\angle B = \phi$, $BX_0 = \ell$, this determines a travelling orbit of reference X_0N , and origin of longitudes X_0 therein; such that, with respect to this travelling orbit, the position of the planet's orbit is determined by

ℓ_0 , the longitude of node,
 σ_0 , the departure of node,
 ϕ_0 , the inclination.

We have in the triangle ABC, $AB = \sigma - \sigma_0$, $\angle B = \phi_0$

$\angle A = 180^\circ - \phi$; and if the other parts of the triangle are represented by

$$\begin{aligned} BC &= \omega, \\ AC &= \theta_0 - \theta + \omega + \Gamma, \\ \angle C &= \Phi; \end{aligned}$$

then ω , Γ , Φ , are given in terms of $\sigma - \sigma_0$, ϕ_0 , ϕ ; and we have, moreover, $XC = \theta + AC = \theta_0 + \omega + \Gamma$, $X_0C = \sigma_0 + \omega$; that is, the position of the travelling orbit X_0N , and origin of longitudes X_0 therein, are determined by

$$\begin{aligned} \theta_0 + \omega + \Gamma, & \text{ the longitude of node,} \\ \sigma_0 + \omega & , \text{ the departure of node,} \\ \Phi & , \text{ the inclination.} \end{aligned}$$

Suppose that in reference to this travelling orbit and origin of longitudes therein, we have

$$\begin{aligned} v', & \text{ the longitude of planet,} \\ y', & \text{ the latitude of ditto,} \end{aligned}$$

viz., in the figure $X_0N = v'$ (and therefore $BN = v' - \theta_0$), $PN = y'$.

Moreover, $BC + CM = BC + AM - AC = \omega + (v - \theta) - (\theta_0 - \theta + \omega + \Gamma) = v - \theta_0 - \Gamma$, hence the two equations are

$$\begin{aligned} \cos y \sin (v - \theta_0 - \Gamma) &= \cos y' \sin (v' - \theta_0) - \tan \frac{1}{2} \Phi \cos \omega (\sin y + \sin y'), \\ \cos y \cos (v - \theta_0 - \Gamma) &= \cos y' \cos (v' - \theta_0) + \tan \frac{1}{2} \Phi \sin \omega (\sin y + \sin y'), \end{aligned}$$

or, as they may also be written,

$$\begin{aligned} \cos y \sin (v - \theta_0 - \Gamma) &= \cos \phi_0 \sin (b - \sigma_0) - \tan \frac{1}{2} \Phi \cos \omega (\sin y + \sin y'), \\ \cos y \cos (v - \theta_0 - \Gamma) &= \cos (b - \sigma_0) + \tan \frac{1}{2} \Phi \sin \omega (\sin y + \sin y'), \end{aligned}$$

or, if we put $s = \sin y + \sin y'$, then observing that $\sin y = \sin \phi \sin (b - \sigma)$, $\sin y' = \sin \phi_0 \sin (b - \sigma_0)$, these become

$$\begin{cases} \cos y \sin (v - \theta_0 - \Gamma) &= \cos \phi_0 \sin (b - \sigma_0) - \tan \frac{1}{2} \Phi \cdot s \cos \omega, \\ \cos y \cos (v - \theta_0 - \Gamma) &= \cos (b - \sigma_0) + \tan \frac{1}{2} \Phi \cdot s \sin \omega, \\ \sin y [-\sin \phi \sin (b - \sigma)] &= -\sin \phi_0 \sin (b - \sigma_0) + s, \end{cases}$$

which are, in fact, Hansen's formulæ (16), p. 75, the letters corresponding as follows, viz.,

$$\begin{aligned} v, b, y, \sigma, \sigma_0, \theta, \theta_0, \phi, \phi_0, \Phi, \Gamma, \omega & \text{ (suprà) to} \\ l, v, b, \sigma, h, \theta, h, i, -h, 2\pi, \Gamma, \omega & \text{ (Hansen).} \end{aligned}$$

where, of course, the correspondence ϕ_0 to $-k$, shows that these angles are measured in a contrary direction. I had from Hansen's equations expected that the above formulæ would have contained $\sin y - \sin y'$ in place of $\sin y + \sin y'$.

2 Stone Buildings, W. C., 4th Dec. 1860.

Observations of Comet III. 1860. By W. Scott, Esq., Director of the Observatory of Sydney.

I send you herewith my latest determinations of the comet's position. The weather was too cloudy for observations during the whole of the time intervening, and for many days following.

The light of the comet was too faint and diffused to admit of satisfactory observations, as will appear from a comparison of the results.

Comet Observations, August 1860.

Greenwich Mean Time.				Star.	Comet—Star R.A.	Comet—Star Decl.
d	h	m	s		m	s
Aug. 16	21	32	56.5	ϕ Centauri	7 34.25	-13 26
	22	37	29.0	"	7 43.50	10 39
	22	48	51.5	"	7 47.00	-10 46
17	21	46	44.5		10.25	1 33
	49	39.5			14.00	2 18
	52	39.5			13.00	2 9
	55	29.25			14.25	2 22
	58	8.75			13.00	2 15
22	1	6.25			13.25	1 59
	3	59.25			14.50	1 48
	7	1.75			16.00	2 13
	9	45.00			15.75	2. 7
	12	35.5			15.75	2 23
	14	58.5			15.75	2 24
	20	48.75			16.25	1 57
	23	25.0			16.75	2 8
	27	2.5			16.50	1 55
	29	53.0			17.00	1 57
	33	0.0			17.25	2 4
	37	45.5			18.00	2 11
	41	30.5			19.00	1 51
	45	37.5			20.00	2 2
	49	1.0			19.00	3 1
	53	53.0			20.25	2 0

Star of 7th or 8th magnitude.
Approximate R.A. $13^h 59^m$
Decl. $-42^{\circ} 0' 42''$ S. Ed.)

Determination of Comet's Position, July 1860.

Greenwich Mean Time.				Star.	Comet—Star. R.A.	Comet—Star. Decl.
^d	^h	^m	^s		^m	^s
July 27	22	27	16.0	Bris. 4134	7 47.0	— 0 57
	22	45	7.5	"	7 51.25	— 0 57
		"		Bris. 4136	7 27.75	4 48
		"		Bris. 4139	6 58.50	3 57
	22	55	35.0	Bris. 4134	7 53.00	— 2 15
		"		Bris. 4139	6 58.25	2 4
		"		a	2 0.75	13 22
	23	8	43.5	a	2 1.75	13 0
	23	13	6.0	a	2 4.00	12 25
		"		b	—0 16.00	13 8
	23	15	48.0	b	—0 14.75	13 13
	23	45	43.5	b	—0 7.25	12 18
		48	40.0	b	—0 6.50	11 20
		53	32.5	b	—0 6.00	11 36
					* —B. 4139	* —B. 4139
					a	4 57.50
					b	7 17.50
2	21	14	11.0	Lacaille 5329	1 27.25	—11 58
		17	59.0	"	1 27.00	—12 23
		31	1.0		1 30.00	—12 37
		36	18.5		1 30.75	—13 19
		42	0.0		1 32.00	—13 3
		47	1.5		1 34.00	—12 58
		51	23.5		1 33.00	—13 13
		55	35.0		1 34.25	—13 29
	22	0	1.5		1 35.25	—13 49
		4	10.0		1 36.25	—13 50
		8	13.5		1 37.00	—13 55
		12	13.5		1 37.75	—14 14
		16	20.0		1 39.25	—14 26
		20	30.0		1 40.00	—14 41
		24	38.0		1 40.75	—14 37
		28	39.0	"	1 42.25	—15 1

Observatory, Sydney, Sept. 19th, 1860.

Observations of the same comet (III, 1860) taken at Ascension Island by Mr. Frederick J. Krabbe, H.M.S. Meander, between the 4th and the 22d July, 1860, have been communicated to the Society by favour of the Lords Commissioners of the Admiralty. The observations are sextant ones of the distances of the comet from certain fixed stars.

Results of Meridional Observations of Small Planets, and Occultation of Jupiter's third Satellite, observed at the Royal Observatory, Greenwich, during the month of November, 1860.

(Communicated by the Astronomer Royal.)

Flora (8).

Mean Solar Time of Observation.			Apparent R.A.	Apparent N.P.D.
	^h _m ^s		^h _m ^s	[°] _' ^{''}
1860, Nov. 1	13 2 1 ²		3 48 7 ⁹⁶	81 6 37 ⁹⁴
2	12 57 13 ⁰		3 47 15 ⁵¹	81 8 52 ⁶²
3	12 52 23 ⁵		3 46 21 ⁸⁰	81 10 55 ¹⁶
7	12 32 52 ⁶		3 42 33 ⁹⁶	81 18 14 ⁶⁶
22	11 18 28 ⁵		3 27 5 ⁹³	81 25 3 ⁶⁹

Metis (9).

Mean Solar Time of Observation.			Apparent R.A.	Apparent N.P.D.
	^h _m ^s		^h _m ^s	[°] _' ^{''}
1860, Nov. 2	6 42 9 ³		21 31 10 ²⁴	111 37 0 ⁶⁰

Eunomia (15).

Mean Solar Time of Observation.			Apparent R.A.	Apparent N.P.D.
	^h _m ^s		^h _m ^s	[°] _' ^{''}
1860, Nov. 2	6 43 33 ⁷		21 32 34 ⁸⁸	91 21 40 ⁵⁵
3	6 40 28 ⁰		21 53 25 ²⁵	91 19 33 ⁸¹

Psyche (16).

Mean Solar Time of Observation.			Apparent R.A.	Apparent N.P.D.
	^h _m ^s		^h _m ^s	[°] _' ^{''}
1860, Nov. 15	12 32 41 ⁴		4 13 55 ¹⁴	73 44 48 ⁹⁵
22	11 58 57 ³		4 7 41 ³⁹	74 2 3 ⁸⁰

Fortuna (19).

Mean Solar Time of Observation.			Apparent R.A.	Apparent N.P.D.
	^h _m ^s		^h _m ^s	[°] _' ^{''}
1860, Nov. 1	12 15 50 ⁶		3 1 49 ⁸⁰	73 28 40 ⁷³
2	12 10 59 ⁶		3 0 54 ⁵⁵	73 33 40 ³⁸
3	12 6 8 ²		2 59 58 ⁹⁴	73 38 43 ⁴⁵
7	11 46 40 ⁵		2 56 14 ²⁰	73 59 13 ⁴³
15	11 7 54 ⁰		2 48 53 ⁸⁶	74 39 37 ⁹⁶

Euterpe (27).

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ' "
1860, Nov. 2 9 45 32.5	0 35 3.60	89 4 10.72
3 9 41 3.4	0 34 30.31	89 6 36.73

Amphitrite (29).

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ' "
1860, Nov. 1 12 31 34.5	3 17 36.32	63 18 51.07
2 12 26 38.0	3 16 35.53	63 19 36.80
3 12 21 41.0	3 15 34.32	63 20 32.60
7 12 1 47.2	3 11 23.39	63 25 49.95
22 10 47 12.1	2 55 44.46	64 4 40.12

Minor Planet (29).

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ' "
1860, Nov. 3 9 16 10.9	0 9 33.73	95 15 36.35
7 8 59 56.7	0 9 3.06	95 25 27.22

Occultation of Jupiter's Third Satellite.

Day of Observation.	Phenomenon.	Mean Solar Time.	Observer.
		h m s	
1860, Nov. 2	Occ. disapp. first cont.	13 15 50.6	D.
	„ last cont.	13 21 49.6	D.
	Occ. reapp. central bis.	17 1 43.7	A. D.
	„ last cont.	17 5 13.2	A. D.

At the reappearance the planet was very faint, in consequence of a fog prevailing.

The initials D. and A. D. are those of Mr. Donkin and Mr. Davis.

Minor Planet (80).

The name *Titania* has been given to this planet. The following is the later of two sets of elements computed by the discoverer, Mr. Ferguson (*Gould Ast. Journal*, No. 141).

Epoch 1860, Oct. 1, Washington M.T.

Mean longitude	199 48 13.8	} Mean Equinox of Epoch.
Longitude of perihelion.....	158 6 45.7	
Longitude of node	187 15 15.8	
Inclination	4 40 18.8	
Excentricity	11 27 10.2	
Log. mean distance	0.359725	
Mean motion	1024".3	

A portfolio of drawings of Solar Spots, by the Rev. F. Howlett, presented by him to the Society, was exhibited at the Meeting. The following is an extract from a letter to Sir J. W. F. Herschel, which accompanied this valuable present:—

“The drawings I now have the honour of submitting to you illustrate (with intermissions, of course, of greater or less duration) the period comprised between 23d Nov. 1859, and 10th Nov. 1860, inclusive; and they consist of about 100 diagrams of the whole solar disk, as seen under a magnifying power of about 30 diameters, and also of some 130 more diagrams of the separate spots, or groups of spots, magnified commonly about 120 diameters.

“It may be seen that many of the drawings were taken at an early hour in the morning, more especially during the months of June, July, and August last past; not only on account of the sky having frequently been very clear and serene at such times, even during this last unusually wet and gloomy summer, but also because the inclination to the horizon of any fixed line on the sun’s disk (such as the line of junction of two spots) changes but very slowly in the earlier hours of the forenoon, and is, in fact, for about an hour or so, nearly unaltered; and thus an excellent opportunity was afforded, at such times, for noting down the relative positions of the spots on the sun’s disk at greater leisure and with greater accuracy than, with the rough micrometric appliances at my command, I could easily have done at any hour nearer to noon, when the change of the obliquity of the sun’s axis to the vertical is very much greater.

“With respect to other points, perhaps of interest in connexion with these diagrams generally, I would remark that the most conspicuous outbursts of spots hitherto this year (so far, at least, as I myself have observed) occurred, firstly, between the 28th June and the 7th, or say 9th of July, as delineated in sheets Nos. xxiii., xxiv., and xxv., wherein also are presented, as well as my ‘Dollond’ of barely 3 inches aperture enabled me to investigate them, certain of the changes successively undergone by the groups more particularly lettered therein ζ and α .

“The second principal outburst might be assigned, I think, to the period between 28th July and 8th Sept. (unless indeed the sun’s rotation in rather more than twenty-five days may have brought some of the later June and earlier July groups again into sight, and which I certainly am inclined to think was the case), as shown in sheets Nos. xxviii. to xxxii. inclusive; wherein likewise are presented the series of changes undergone by group μ , for instance, in xxviii. and xxix., and still more by ϵ in xxxi. and xxxii. The spot θ in No. xxv. (which also was observable on the day of the solar eclipse in July last) is likewise rather worthy of notice.

“As regards the darkest part of the nucleus of a spot (so

frequently and so distinctly brought out by the Rev. Mr. Dawes' method of investigating them, as stated in your 'Outlines of Astronomy') this phenomenon was very apparent even without any such method, in the spot β of 23d Nov. 1859, in sheet No. ix.; and again, on the 4th and 7th Sept. 1860, in the right-hand nucleus of spot ϵ , in No. xxxii.

"The large spot ζ , of 1st July, 1860, presented a very singular step-like appearance (No. xxiii.). At this period also, as well as on the 28th and 29th June, I observed a nucleus in this group more nearly approaching in form those curious wedge-shaped ones which were represented in my drawings of 28th August, 1859, than any others which have occurred, I believe, since the date just mentioned. The changes undergone by the group ζ , between its first appearance about 27th June and its disappearance, were very striking, more especially in the interval between the 1st and 2d July (see sheets xxiv. and xxv.)

"On the 22d June I noticed near the western limb of the sun a facula which appeared to extend, in a wavy continuous streak, to a length of at least 150,000 miles on the sun's surface, as faintly indicated in the disk of that day in No. xxii.

"The predominance of spots in the sun's northern hemisphere was, perhaps, not so decided this year as usual, though it was sufficiently marked during the great outburst in June and July last."

And appended to the letter was an account of the method adopted for noting down the positions of the spots on the disk; the co-ordinates employed are, in fact, those of Pastorff, viz., the distances in two directions at right angles to each other, of the point from the circumference of the disk. It has already been remarked by Mr. Carrington that the employment of such co-ordinates is anything but convenient.

There were exhibited at the Meeting four photographs of the Sun during the Eclipse of the 18th July, 1860, obtained at Desierto de las Palmas in Spain, by M. Monserrat, Professor of Chemistry at the University of Valencia, with the telescope by Cauchoix of the Observatory of the Collegio Romano, brought by the Director, P. Secchi. The photographs were communicated to the Astronomer Royal by Signor Aguilar, the Director of the Madrid Observatory.

At the Meeting in November were exhibited two lithographic drawings of Nebulæ, accompanied with a printed

description, presented by Mr. Lassell. The one of them represented the Annular Nebula in *Lyra*, R.A. $18^h 48^m.4$, N.P.D. $57^\circ 8'$, as seen in the 4-foot equatoreal, power 174, the field of view being about $5''.68$ in diameter, the scale of the drawing was $1'' = 0.015$ inch. The greater axis of the nebula is about $89'$, and the lesser about $68''$, by micrometrical measurement. The other drawing was a representation of the "Dumb Bell" Nebula, as seen with the 4-foot equatoreal, and the same power and field of view as was employed in the drawing of the Annular Nebula of *Lyra*.

RECENT PUBLICATIONS.

Recueil de Mémoires des Astronomes de l'Observatoire Centrale de Russie, publié avec l'autorisation de l'Académie des Sciences, t. II. Pet. 1859.

The first volume of this Collection, published 1853, and containing various important memoirs by MM. Struve, Peters, Döllén, Lindhagen, O. Struve, and Liapounov, is well known to astronomers. The present and concluding volume contains memoirs by M. O. Struve on the chronometrical expeditions in the years 1845 and 1846, and on the geographical positions determined by Lieut.-Col. Lemm, in 1847 in the country of the Don Cossacks, and in 1848 in the Government of Novgorod; the volume contains also the Pulkova observations of Biela's comet in the year 1852, with two plates of the comet as seen on the 20th Sept. and the 25th Sept. 1852; for a notice of these observations see *Monthly Notices*, vol. xvi. p. 137. M. O. Struve in the preface states that in consequence of the new regulations adopted by the Academy of Sciences at St. Petersburg, the collection will cease to appear in its actual form, but that a fixed number of copies of the astronomical memoirs will be put at the disposition of the Central Observatory, and that the scientific establishments, and Russian and foreign *savans*, who have received from the Observatory the two volumes of the Collection, will receive each separate astronomical memoir as it is printed, and that the works of the Russian astronomers will thus be more speedily brought to the knowledge of the astronomical public. The two memoirs next referred to have in fact already appeared in the new form; and the preface announces also the speedy publication of two other memoirs, by MM. Liapounov and O. Struve, on the great nebula of *Orion*.

Nouvelle Determination de la Parallaxe Annuelle des Etoiles α Lyræ et 61 Cygni. Par M. O. Struve, Mém. de l'Acad. de St. Pet. VII. Serie, t. i. No. 1.

The observations upon which these determinations are founded were made at the Pulkova Observatory in the years 1851-52, and an abstract of the memoir is published in the *Bulletins* of the Academy, t. xiii. (1855), p. 283, so that the results of the investigation have been for some years in the possession of astronomers. See also *Monthly Notices*, vol. xiii. p. 74, and vol. xiv. p. 159.

Pulkowaer Beobachtungen des Grossen Cometen von 1858. Erste Abtheilung, Beobachtungen am Refractor angestellt von O. Struve. Zweite Abtheilung, Beobachtungen am Heliometer nebst Untersuchungen ueber die Natur des Cometen von Dr. A. Winnecke. Mit sechs Tafeln. Gelesen am 29 Ap. 1859. Mém. de l'Acad. de St. Pet. VII. Serie, t. ii. No. 1 (1859).

The comet was first seen at Pulkova on the 16th August in the refractor, and with the naked eye on the 19th August; but, on account of the smoke from the burning of the morasses, no observations could be taken in that month; and the observations of position and configuration recorded in the memoir extend from the 2d Sept. to the 13th Oct. 1858. There are several elaborate drawings of the comet.

Librorum in Bibliotheca Speculæ Pulcovicensis Anno 1858 exeunte contentorum Catalogus Systematicus: Edendum curavit et præfatus est Otto Struve. Petropoli, 1860.

The Library of the Pulkova Observatory, in the year 1845, when the former Catalogue was published, comprised
2068 works, contained in 4150 volumes,
60 celestial charts, and
3109 memoirs and smaller works.

The present catalogue to the end of the year 1858 shows
4113 titles of works, contained in 7625 volumes,
143 celestial charts, and
14,634 titles of memoirs and smaller works;
but the titles of a large proportion of the memoirs are taken from Transactions of Societies and other collective works.

The Catalogue is divided into two parts; the former of

them (pp. 1-262 and 819-830) comprising the separate works (*libri majores*), and the latter (pp. 265-818 and 831-857) the memoirs, &c. (*libri minores et dissertationes*), and in each part the arrangement is a classified one, according to subjects; there being also to each of them an alphabetical index of authors' names. It might, perhaps, have been preferable to blend together these two indices. The arrangement is a most admirable one; and not only with respect to astronomy, but even as regards pure mathematics, the catalogue will be most valuable as a work of reference. If it were not that the work itself ought to be in the hands of all concerned, it would be worth while to exhibit the divisions and subdivisions of the subjects, as shown by the contents or *Systema Catalogi* (pp. xxv.-xxx.) of the introduction.

Anseinandersetzung einer zweckmässigen Methode zur Berechnung der absoluten Störungen der kleinen Planeten. Von P. A. Hansen (Abhandlungen der k. Sächs. Gesell. zu Leipsig. Erste Abh. t. v. pp. 44-218, 1856; Zweite Abh. t. vi. pp. 3-148, 1857; Dritte Abh. t. vii. pp. 83-335, 1859).

Only a short account can be given of these elaborate and important memoirs. The method is, in its general character, similar to M. Hansen's method in the lunar theory, viz. it is assumed that the longitude in orbit (departure) and the radius vector are functions, the former of the same form and the latter of the same form (except that the expression contains a variable factor which has to be determined) as in the elliptic theory, but instead of the mean anomaly there is a function z of the form $nt +$ periodic and secular terms, the expression for which has to be determined by the theory. The perturbations of the plane of the orbit are taken account of in a very elegant manner. The development of the disturbing function is effected in terms of the eccentric anomalies of the two planets: it is stated that a greater convergency of the series is thereby obtained. The values of the coefficients are found by the method of quadratures. The method is applied to the calculation of the perturbations of *Egeria*. The perturbations depending on the first powers of the masses of *Jupiter*, *Saturn*, and *Mars*, are obtained in the second memoir; those depending on the powers and products of the second order (viz. (*Jupiter*)² and *Jupiter* $\times$ *Saturn*, which are considered as the only sensible cases) are obtained in the third and concluding memoir, which, as the author remarks, affords the first instance of the calculation of the perturbations of the second order for one of the

On the Secular Variations and Mutual Relations of the Orbits of the Asteroids. By Simon Newcomb. (Memoirs of the American Academy, New Series, t. v. pp. 123-135, Communicated 24th April, 1860.)

The following is an outline of this interesting memoir. The object is stated to be the examination of those circumstances of the forms, positions, variations, and general relations of the asteroid orbits, which may serve as a test, complete or imperfect, of any hypotheses which may be made respecting the cause from which they originated, or the reason why they are a group by themselves. Every *à priori* test is founded on the supposition that the hypothesis to be tested necessarily or probably implies that certain conditions must be fulfilled by the asteroids or their orbits. The tests consist in observing whether these conditions are fulfilled. The conditions may be divided into two general classes,—those which are rigorous and necessary, and those which are merely probable. The nature of the latter conditions appears from the examples which are subsequently given of their deduction from hypotheses.

Two hypotheses worthy of consideration have been promulgated respecting the origin of the asteroids: one (Olbers' hypothesis), that they are the fragments of a single planet, shattered by some unknown cause; the other, that they were formed by the breaking up of a revolving ring of nebulous matter.

To apply rigorous tests to either of these hypotheses it is necessary to have rigorous expressions in terms of the time, for the values of the excentricity, inclination, longitude of perihelion, and longitude of node of each asteroid used in applying the test. For the probable tests it is necessary to have the mean and the limiting values of the same elements; and to obtain these the same expressions are required.

The subject is arranged under the following heads:—

- § 1. Computation of the rigorous expressions in terms of the time, of the elements of the asteroids.
- § 2. On the possibility that the orbits of all the asteroids once intersected in a common point.
- § 3. Have the elements of the asteroid orbits ever been materially affected by a resisting medium?
- § 4. Of the relations among the mean distances, excentricities, and inclinations of the orbits of the asteroids; and between their masses and the velocities with which they must have been projected, if Olbers' hypothesis be true?
- § 5. Of certain observed relations among the asteroids which are the necessary or probable result of known causes, and, therefore, throw no light on the origin of the asteroids.

The investigations of § 1 are the mathematical basis of the memoir. The secular variations h, l ($= e \sin \omega, e \cos \omega$), and p, q ($= i \sin \Omega, i \cos \Omega$), of an asteroid, are to be deduced from the expressions given in the *Mécanique Céleste*, liv. ii. § 55 and 59. In these expressions h, l , are determined by linear differential equations, which involve (besides l, h) the corresponding quantities $l', h', l'', h'',$ &c. for the disturbing planets, and in like manner p, q , are determined by linear differential equations, which involve (besides q, p) the corresponding quantities $q', p', q'', p'',$ &c. for the disturbing planets. But the actions of the asteroids on each other, and on the larger planets, are neglected; $l', h', p', q',$ &c. relate, therefore, to the larger planets, and are considered as known functions of the time,—the numerical values for the planets considered are taken from t. ii. of the *Annales de l'Observatoire de Paris*. The remaining quantities in the equations depend on the mean distance of the asteroid, and they are tabulated in the memoir for every .05 in the value of the mean distance, between the limits 2.20 and 3.20, of the asteroids. The data are then applied to the asteroids the elements of which are determined with sufficient accuracy, and the excentricities and inclinations of which are sufficiently small; the latter class being presumed to include all those for which each of these elements is less than 11° ; and in this manner expressions for h, l, p, q , in terms of the time, are obtained (pp. 133–137) for the asteroid,—*Ceres, Vesta, Astræa, Flora, Metis, Hygeia, Parthenope, Irene, Psyche, Thetis, Fortuna, Massilia, Lutetia, Themis, Proserpina, Euterpe, Bellona, Amphitrite, Urania, Pomona, Circe, Fides, Leda, Lætitia, Harmonia*.

From these expressions are deduced the following conclusions:—

1. *Harmonia* is the only asteroid among those the elements of which are well determined, the orbit of which can ever approach indefinitely near the circular form. *Doris* may possibly be found to be an additional asteroid in this class.
2. *Euterpe* is the only known asteroid the orbit of which can ever approach indefinitely near the invariable plane of the planetary system.
3. The perihelion of each asteroid (*Harmonia, Doris*, and *Euterpe*, only excepted) revolves nearly in the same time as its node, the time of revolution varying from about 15,000 to 40,000 years.
4. The excentricities and inclinations to the invariable plane, of the asteroids considered, cannot exceed the values given in the memoir for the same asteroids respectively.

§ 2. If Olbers' hypothesis be true the orbits must once have had a common point of intersection.

It appears that under the assumption of the investigation the orbit of *Hygeia* could never have intersected with that of *Vesta, Flora, Metis, Urania*, or *Harmonia*; and that the orbit

of *Psyche* could never have intersected with that of *Flora* or *Urania*. But as two asteroids might, by their mutual attraction if they came sufficiently near, change each other's mean distance very materially, the result cannot be considered as conclusive against the hypothesis, and it does not seem possible absolutely to disprove the hypothesis by an attempt at rigorous computations of the secular variations of the asteroids.

§ 3. The conclusion arrived at is that, if the motions of the asteroids are affected by a resisting medium, the former positions of some of the orbits were more unfavourable for a common point of intersection than their present ones.

§ 4. On all probable hypotheses on the cause of an explosion of a planet—the smaller fragments ought on the whole to be thrown off with a greater velocity than the larger ones. Moreover, when (as in the case of the asteroids) each fragment is small compared with the original mass, it seems at least highly probable that the velocities of those thrown off in any one direction would be very nearly the same on the whole as the velocities of those thrown off in a direction at right angles to that of the former one. There are thus two probable tests of Olbers' hypothesis. It appears that there is a remarkable agreement of the circumstances of the asteroids with the second test, and this favours Olbers' hypothesis, but no such relation exists as is supposed by the first test.

§ 5. The conclusion appears to be that certain peculiarities which have been observed as to the distribution of the perihelia and nodes of the asteroids, and other observed relations, do not furnish any argument for or against Olbers' hypothesis. But it has been suggested that the inclinations are usually small, because the asteroids are looked for near the plane of the ecliptic, and (this being so) it seems probable that the mean inclination of the whole number of the asteroids, known and unknown, is much greater than that of the known asteroids; and according to the author the fact, if so, furnishes an additional argument against the hypothesis of explosion.

Brünnow's Spherical Astronomy; translated by the Rev. R. Main. Part I., including the chapters on Parallax, Refraction, Aberration, Precession, and Nutation. Cambridge, 1860.

The excellence of the original work is well known; the translator remarks that the want of a text-book for Spherical Astronomy has been long felt at Cambridge and in the other universities of the British Isles in which the mathematical sciences are cultivated. And he hopes that the translation,

although incomplete, may be of considerable service, since, with the exception of the detailed accounts, given in the latter portion of the original work, of the construction and use of instruments and of the methods employed by modern astronomers for deducing from observations the most accurate values of the constants employed in Astronomy, the portion printed contains nearly the whole which would be valuable to English students; in particular, the theories of Parallax, Refraction, Aberration, Precession, and Nutation, are given in a more complete form than is to be found in any English work.

Tables for facilitating the Reduction of Lunar Observations.

By C. F. A. Shadwell, Esq., C.B., Captain R.N., London, 1860.

The formulæ from which the lunar tables are derived were originally proposed by the late Lieut. Henry Raper, R.N., in the 18th volume of the *Monthly Notices*. The author remarks, "Rigorous, elegant, and concise, Raper's formula can scarcely fail to recommend itself to the notice of the scientific student—while the brevity and simplicity of the tables necessary for its practical application give the method of reduction derived from it great claims to the attention of the practical navigator."

The work is divided in two chapters; the first contains the theory of the method; the second, practical rules, with examples, illustrating their application. The tables are comprised in the concluding pages, 54–63, of the work. In Chapter I. the opportunity is taken to explain, and in some measure to criticise, the various rules and tables for solving the problem, depending on Lyons' formula, which have been published from time to time by various authors. It is remarked that Lyons' formula ranks high among the approximate methods which have been devised for solving the lunar problem; Raper's formula, however, while equally brief and quite as easy in numerical solution, has the advantage of affording a rigorous mathematical result; and that, while equally available at sea with other methods, it is therefore peculiarly suited for the reduction of lunar observations on shore, where extreme precision is required. It may be anticipated that the work will, as the author hopes, prove acceptable to practical navigators and scientific travellers, and be received as a useful contribution to nautical astronomy.

In the *Bulletins* of the 6th, 7th, and 8th Dec. 1860, M. Le Verrier gives an account of his "Théorie et Tables du Mouvement de *Venus*." The work is divided into five sections.

Section 1 is devoted to the perturbations of *Venus* by *Mercury*, the Earth, *Mars*, *Jupiter*, &c. All the terms which rise to the half-hundredth of a second are scrupulously taken account of. The long inequality depending on 13 times the mean motion of the Earth less 8 times the mean motion of *Venus*, the discovery whereof is due to Mr. Airy, has been determined anew, the approximation being carried to the terms of the seventh order as regards the excentricities and the inclinations. Among the terms depending on the second power of the disturbing force, that depending on 4 times the mean motion of *Mars* less 3 times the mean motion of *Venus* less 7 times the mean motion of the Earth, is sensible, as in the theory of the motion of the Earth. It has been determined with care. The formulæ for the secular inequalities of *Venus* show that the action of *Mercury*, taking the mass at $\frac{1}{300000}$ of the mass of the Sun, amounts to two-thirds of the action of the Earth; it is thus very sensible, and the observations of *Venus* during the last century ought to conduct to a reliable determination of the mass, still so imperfectly known, of *Mercury*.

Section 2 contains the establishment of all the formulæ necessary in the theory of *Venus*.

In Section 3 are collected all the observations of *Venus* which are made use of. The more ancient observations are of no service; the available ones are:—1, a series of meridian observations from Bradley in 1750 to the present time; 2, observations of the transits of 1761 and 1769, and, to a certain extent, the transit of 1639; 3, a remarkable observation of an occultation of *Mercury* by *Venus*, made at Greenwich in the year 1737, and which some circumstances render very precious. The "Reduction of the Greenwich Observations of Planets from 1750 to 1830" has been largely made use of; and as the positions of the stars employed in the reductions are there given, M. Le Verrier has been able to introduce the modifications arising from his own discussion of Bradley's star-observations. As the precision of observation of the occultation of *Mercury* by *Venus* was unknown, this observation was not used in the determination of the elements of the tables, but it afforded a verification of the tables.

Section 4 contains the results of the comparison of the theory with the observations.

The recent observations give the elements of the motion of the planet at the present time; and the ancient ones, which give the mean motion, are also the only ones which can lead to the values of the disturbing masses of *Mercury* and the Earth. Taking the mean motion of the planet from the observations of the transits of 1761 and 1769, the mass of *Mercury* can only be deduced from the longitudes given by Bradley's meridian ob-

servations. And these lead to sufficiently precise results, from which it appears that the mass of *Mercury* should be reduced to about $\frac{1}{300000}$ of the mass of the Sun, which agrees with the result obtained by M. Encke from his comet of short period.

The mass of the Earth is obtained chiefly from the observations of the latitude. The aggregate of the observations of the transits of 1761 and 1769 give a first equation, and a second one is deduced from the aggregate of Bradley's observations of the latitudes. These two equations agree in showing that the received mass of the Earth must be augmented by about *one-tenth* of its value—the lunar equation in the theory of the motion of the Earth had already shown that the mass of the Earth required to be considerably augmented.

Section 5 comprises the tables, xxxviii. in number, necessary for the calculation of the places of the planet. The tables satisfy all the known observations. They represent very well the aggregate of the meridian observations, and satisfy the observations of the transits, including that of 1639 in the limits of its accuracy. It appears, also, that using them concurrently with M. Le Verrier's tables of *Mercury* and of the Sun, to calculate the occultation of *Mercury* by *Venus* in 1737, the agreement affords a remarkable confirmation of the accuracy of the tables of the Sun, of *Mercury*, and of *Venus*.

The theory of *Venus*, based on the reciprocal action of the sun and the planets, presents no anomaly. The theory of Universal Gravitation, applied to known physical causes, gives a perfect account of the motion of the Earth and of *Venus*; more than this, it does the same with respect to *Mercury*, except as to a single point, the secular variation of the perihelion; and it is impossible to doubt (M. Le Verrier concludes) but that the ring of small planets interior to the orbit of *Mercury*, the consideration whereof is indispensable to remove this discrepancy, has a real existence.

Note sur les Inégalités Lunaires à longues Périodes dues à l'action perturbatrice de Vénus. Par M. Delaunay. (Extract.)

(Communicated by the Astronomer Royal.)

La discussion des observations de la Lune ayant amené les astronomes à admettre dans son mouvement l'existence d'une ou de plusieurs inégalités à longue période, on a cherché à en trouver la cause dans les actions perturbatrices auxquelles cet astre est soumis. C'est ainsi que M. Hansen a trouvé que l'action

de *Vénus* introduit dans la valeur de la longitude de la lune les deux inégalités suivantes :

$$+ 27''.4 \sin (-l - 16 l' + 18 l'' + 35^{\circ} 20' 2'') \\ (\text{période de 273 années})$$

$$+ 23''.2 \sin (8 l' - 13 l'' + 315^{\circ} 20'), \\ (\text{période de 239 années}).$$

l, l', l'' , étant respectivement les anomalies moyennes de la Lune, de la Terre, et de *Vénus*. La première de ces deux inégalités est produite par l'attraction directe de *Vénus* sur la Lune; en ne tenant compte que de la première puissance de cette action perturbatrice, M. Hansen avait trouvé $16''.01$ pour son coefficient: c'est en poussant l'approximation jusqu'aux quantités de l'ordre du produit du cube de la force perturbatrice du soleil par la masse de *Vénus* qu'il a dû porter ce coefficient de $16''.01$ à $27''.4$. La seconde inégalité dépend en partie de l'attraction directe de *Vénus* sur la Lune, et en partie de cette attraction réfléchie par l'intermédiaire de la Terre; son argument est celui pour lequel M. Airy a montré le premier qu'il a un coefficient sensible dans le mouvement de la Terre. Ces résultats obtenus par M. Hansen ont été communiqués par lui à l'Académie des Sciences de Paris dans sa séance du 5 Mai, 1847; il annonçait en même temps qu'il se proposait de refaire le calcul des deux inégalités qu'il avait trouvées, parce que leurs coefficients ne lui paroissoient pas déterminés avec toute l'exactitude désirable.

M. Hansen revient sur ces inégalités à longues périodes produites par *Vénus*, dans une lettre adressé à M. Airy, au sujet de la construction de ses Tables de la Lune, et insérée dans les *Monthly Notices* (Novembre 1854). Voici ce qu'on y lit à l'occasion de la différence entre la valeur qu'il adopte pour le moyen mouvement de la Lune et celle que M. Airy avait précédemment obtenue: ". . . This arises from the circumstance that I have slightly altered the coefficients of the two inequalities of long period. The accurate determination of these two inequalities by theory is the most difficult matter which presents itself in the theory of the moon's motion. I have on two occasions, and by different methods, sought to determine their values, but I have obtained results essentially different from each other." On trouve, en effet, dans le préambule des Tables de la Lune de M. Hansen, que les deux inégalités dont il est question y ont été introduites avec les valeurs suivantes:—

$$+ 15''.34 \sin (-l - 16 E + 18 V + 30^{\circ} 12') \\ + 21''.47 \sin (8 V - 13 E + 274^{\circ} 14').$$

V designant la longitude moyenne héliocentrique et sidérale de

Vénus, E celle de la Terre, et l l'anomalie moyenne de la Lune. Les coefficients qui, comme on le voit, diffèrent notablement de ceux que M. Hansen leur avait d'abord attribués, et que nous avons rapportés plus haut, paraissent avoir été choisis de manière à satisfaire convenablement aux observations tant anciennes que modernes, et présentent ainsi un caractère purement empirique.

Ce point de la théorie de la Lune a dû naturellement attirer mon attention, en raison de l'incertitude qui en résulte sur la réalité de l'existence des deux inégalités trouvées par M. Hansen, ou au moins sur la grandeur de leurs coefficients. Je me suis donc occupé d'en effectuer moi-même la détermination, en profitant de mes recherches antérieures sur le mouvement de la Lune. L'objet de cette note est de faire connaître les résultats aux quels je suis parvenu.

Relativement à la première des deux inégalités de M. Hansen, les calculs aux quels je me suis livré m'ont conduit à une confirmation partielle de ses résultats. En m'en tenant d'abord à la première puissance de l'action perturbatrice de *Vénus* sur la Lune, j'ai trouvé pour cette inégalité

$$+ 16''\cdot024 \sin (-l - 16 l' + 18 l'' + 35^\circ 20' \cdot 2),$$

valeur identique avec celle que M. Hansen avait obtenue dans le même cas. Mais ensuite, en poussant les approximations plus loin, c'est à dire en allant jusqu'aux quantités de l'ordre du produit de la masse de *Vénus* par le cube de la force perturbatrice du soleil dans les termes indépendents de l'inclinaison de l'orbite de *Vénus* sur l'écliptique, et jusqu'aux quantités de l'ordre du produit de la masse de *Vénus* par la cinquième puissance de la force perturbatrice du soleil dans les termes qui dépendent de cette inclinaison, je n'ai obtenu qu'une très-légère modification à mon premier résultat: j'ai trouvé pour l'inégalité

$$+ 16''\cdot336 \sin (-l - 16 l' + 18 l'' + 35^\circ 16' \cdot 5).$$

Ainsi les approximations ultérieures n'ont fait qu'augmenter son coefficient de $0''\cdot312$. La détermination numérique de cette inégalité a été faite en adoptant, comme M. Hansen, $\frac{108134}{108134}$ pour le rapport de la masse de *Vénus* à celle du soleil. Si l'on prenait pour ce rapport la valeur plus grande $\frac{108000}{108000}$ qui paraît mieux s'accorder avec les perturbations produites par *Vénus*, le coefficient de l'inégalité dont nous nous occupons devrait être porté de $16''\cdot336$ à $16''\cdot668$.

Le résultat auquel je suis arrivé pour la seconde des inégalités de M. Hansen est tout différent: au lieu des coefficients $23''\cdot2$ et $21''\cdot47$ qui M. Hansen lui a attribués successivement, j'ai trouvé que son coefficient est à peu près nul. Suivant lui, cette inégalité est due en partie à l'attraction directe de *Vénus*

sur la Lune, et en partie à cette attraction réfléchie par l'intermédiaire de la Terre. J'en ai effectué la détermination en tenant compte de ce double mode d'action de la planète troublante. La partie de cette inégalité qui provient de l'attraction de *Vénus* réfléchie par l'intermédiaire de la Terre, résulte de l'existence de l'inégalité de même argument trouvée par M. Airy dans le mouvement de la Terre autour du soleil; j'ai pu facilement m'assurer qu'elle ne s'élève pas à $\frac{1}{4}$ de seconde. Quant à la partie de l'inégalité en question qui est due à l'action directe de *Vénus* sur la Lune, j'en ai fait le calcul en poussant les approximations assez loin pour ne pas craindre d'obtenir un résultat inexact, et j'ai reconnu qu'elle est absolument insensible.

D'après ce qui précède, la première des deux inégalités lunaires à longues périodes dues à l'action perturbatrice de *Vénus* doit seule être prise en considération dans les Tables; et son coefficient, qui je trouve égal à $16''\cdot668$, diffère peu de celui ($15''\cdot34$) auquel M. Hansen s'est arrêté pour satisfaire convenablement aux observations.

Le mémoire dans lequel j'ai développé en détail les calculs relatifs à la première inégalité, a été imprimé dans les *Additions à la Connaissance des Temps pour 1862*. Un second mémoire, contenant tous les détails du calcul de la seconde inégalité, paraîtra incessamment.

Note by the Astronomer Royal.

As several allusions have lately been made to the degree of empiricism in Professor Hansen's determination of the coefficients of the two long inequalities of the moon produced by the disturbing force of *Venus*, to which Professor Hansen has adverted in his letter of 1854, Nov. 3 (of which letter a translation is printed in the *Monthly Notices* of 1854, Nov. 10), I think it desirable to give the original of the most important sentence, and to annex what appears to be a correct translation.

The original is —

“In meinen Mondtafeln habe ich einstweilen Coefficienten angewandt, die nicht frei von einigen Empirismus sind.”

The correct translation appears to be —

“In my Lunar Tables I have provisionally applied coefficients which are not free from some empiricism.”

*Royal Observatory, Greenwich,
1860, December 28.*

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MONTHLY NOTICES
OF THE
ROYAL ASTRONOMICAL SOCIETY.

Vol. XXI. January 11, 1861.

No. 3.

The Rev. R. MAIN, President, in the Chair.

J. Stuart Stuart Glennie, Esq., 6 Stone Buildings, Lincoln's Inn;

Henry George Bohn, Esq., York Street, Covent Garden;

Philip E. Sewell, Esq., Fuente del Mar, Santander;

John M. Stothard, M.D., 11 Lower Sherrard Street, Dublin;

E. J. Stone, Esq., First Assistant, Royal Observatory, Greenwich; and

C. P. Mason, Esq., Denmark Hill Grammar School,

were balloted for and duly elected Fellows of the Society.

On the Binary Star α Cassiopeæ.

By Eyre B. Powell, Esq.

I believe up to this time no orbit has been put forward for the binary star, α Cassiopeæ; I am aware of attempts having been made in past years to arrive at elements by two or three individuals beside myself, but the results proved altogether unsatisfactory, owing to the irregularities existing among the early observations, especially those of distance. I now do myself the pleasure of laying before the Society an approximate orbit, at which I have arrived after the expenditure of no little trouble; but, in so doing, I wish it to be understood that, in consequence of the peculiar circumstances of the case, I do not claim for the elements any higher rank than that of a *first* approximation to the truth.

Some of the early distance measures are utterly irreconcilable with one another; and, perhaps, the most important, that of the founder of this branch of astronomy, Sir William

Herschel, is shown to be considerably too small by Kepler's law of areas. The angle of true anomaly, moreover, which has been described since 1779, falls short of 40° , and is so situated as not to afford a good grasp of the orbit. Any conclusions, therefore, which may be drawn at present must necessarily be insecure. Still, as it will take some thirty-five years for the *comes* to round the vertex of the apparent ellipse and reach its periastræ, before which time a close approximation to the elements will scarcely be attainable, there seems no reason for deferring the attempt to reduce the motion in some degree to line and measure.

After some previous approximations I arrived at the following elements, using for the most part Sir John Herschel's graphical method, and calculating n and τ by means of different pairs of equations, the final sets of which afforded results in fair agreement with each other. Here I may remark in passing that this way of determining the mean motion and the time of periastral passage seems to me decidedly the best, when once the perspective ellipse has been fixed with tolerable accuracy.

Apparent Orbit.

Axis major	= $15''.8$
Axis minor	= $9''.2$
Maximum distance	= $12''.84$
Position angle for do.	= 60°
Minimum distance	= $1''.3$
Position angle for do.	= $238^\circ 10'$
C A, projection of semi-major axis of real orbit	= $6''.72$
C B, projection of semi-minor axis of real orbit	= $6''.1$
C S, projection of linear excentricity of real orbit	= $5''.18$
Position angle for S A	= $252^\circ 30'$
Position angle for focal distance parallel to C B	= $190^\circ 50'$

Elements of Real Orbit.

ϖ	= $252^\circ 30'$
e	= $.770833$
Ω	= $25^\circ 33'$
γ	= $57^\circ 59'$
a	= $10''.335$
n	= $1^\circ.989$, P = 181 years nearly,
τ	= 1715°

The annexed table exhibits the degree of correctness with which the elements represent the recorded motion of the star; in it I have taken the most reliable of the observations within my reach, and in many cases have used the means of nearly contemporaneous groups.

Date.	P_0	$P_0 - P_0$	D_0	$D_0 - D_0$	Observer.	Remarks.
1779'63	62 4	- 96	11'27	+ 1'43	H	$P_0 = 60' 6''$ for 1782'4, according to h, in vol. v., R. Ast. Soc. <i>Memoirs</i> . The value here is from the <i>Phil. Trans.</i>
1803'1	70 46	+ 32			H	
1819'8	80 12	+ 10	10'8	+ '13	Σ	
1825'78	83 5	+ 61	9'9	+ '54	S	
1830'17	87 13	- 6	10'1	- '04	h, Sm	h., 1829'43; Sm., 1830'91.
1833'3	89 1	+ 24	9'91	- '14	{ Sm, D, Sm, Sm. }	Sm., 1831'84; D., 1832'87; Sm., 1833'7; Sm., 1834'77.
1836'79	92 0	+ 6	9'43	+ '01	Σ, Sm	Σ. and Sm. in admirable agreement. Σ., 1836'78; Sm 1836'81.
1843'19	95 48	+ 109	9'1	- '28	Sm	On examining the interpolating position curve, P_0 is clearly seen to be too small.
1847'42	102 0	+ 47	8'65	- '36	J	
1851'84	106 38	- 7	8'06	- '07	J, J, J	1850'876; 1851'89; 1852'76.
1853'68	109 23	- 42	7'95	- '21	J, J, P	J., 1853'14; P., 1853'92; J., 1853'99.
1856'0	112 26	- 56	7'6	- '06	J, P	J., 1856'07; P., 1855'93.
1857'56	114 2	- 30	7'45	- '11	J, J	1857'06; 1858'06.
1859'72	116 35	- 5	7'02	+ 1'1	P	

H, Sir W. Herschel; Σ, Professor Struve; S, Sir J. South; h, Sir J. Herschel; Sm, Admiral Smyth; J, Captain Jacob; P, myself.

Owing to the unfavourable weather here, I have not secured any recent observations of α .

For the purpose of comparing the orbit with future observations I append the calculated places of the *comes* for the next five years.

Date.	Position.	Distance.
1861'0	118 21'	6'99
1862'0	119 51	6'89
1863'0	121 21	6'79
1864'0	122 58	6'69
1865'0	124 35	6'59

It is to be remarked, however, that the arc which will be described during the next ten or twelve years may be made, within moderate limits of error, to belong to different ellipses partaking of an osculating character.

Madras, December 1, 1860.

On the Three New Variable Stars, T Bootis, T Serpentis, and S Delphini. By Joseph Baxendell, Esq.

1. The first of these variables precedes *Arcturus* $1^m 45^s$, and is $11' 30''$ more south. It was mapped down as a $9\frac{1}{2}$ magnitude star on the 9th of April last, and on the 11th it was again seen and estimated to be of the 10th magnitude; but on the 22d it had diminished to the 12·8 magnitude, and on the following night it was invisible with Mr. Worthington's 13-inch reflector, in a sky which permitted stars of the 14th magnitude to be seen. It has frequently been looked for since, but not seen.

2. On the 12th of July last, while comparing with the heavens a chart of the cluster No. 72 of Sir W. Herschel's 8th class, I observed a star of the 11th magnitude in a position in which none was laid down on the chart, and on referring to the notes appended to my measures of the positions of the neighbouring stars I satisfied myself that this star was not visible, or, at all events, not brighter than the 13th magnitude in July and August 1859, when the chart was constructed. It had a deep yellowish red colour, which alone would have drawn attention to it had it been visible during my previous examinations of the cluster. For several days its brightness appeared to remain unchanged, but afterwards it diminished very gradually, and on the 13th of September it was no longer visible with Mr. Worthington's large reflector, and was therefore below the 14th magnitude. From the course of its curve of variation it appears probable that it had already passed a maximum when first seen on the 12th of July. Its place for 1860 is $18^h 21^m 59^s$, $+6^\circ 12' 7''$.

3. The third variable is No. 4351 Zone $+16^\circ$ of the *Bonn Catalogue*, its place for 1855 being $20^h 36^m 24^s 1$, $+16^\circ 34' 2''$. On the 25th of September, 1860, I was surprised to find it a full magnitude brighter than I had ever before seen it, being equal to its neighbour, No. 4350, of the 8·3 magnitude, the two thus forming a fine but wide double star. From the 28th of September to the 8th of October it was thought to be slightly brighter than 4350, but in the beginning of November it had become sensibly less bright, and on the 18th of December it had diminished to the 11th magnitude, at which it has since remained. It was observed as a 9th magnitude star by Bessel on October 7, 1823, in Zone 192. In the *Bonn Catalogue* its magnitude is 9·5.

Manchester, Jan. 9, 1861.

*Results of Meridional Observations of Small Planets; and
Phenomena of Jupiter's Satellites; observed at the Royal
Observatory, Greenwich, during the month of December,
1860.*

(Communicated by the Astronomer Royal.)

Flora (8).

Mean Solar Time of Observation.		Apparent R.A.	Apparent N.P.D.
h m s		h m s	° ' "
1860, Dec. 17	9 22 51.80	3 9 44.21	80 5 25.11
18	9 18 40.06	3 9 28.35	79 59 54.44

Psyche (16).

Mean Solar Time of Observation.		Apparent R.A.	Apparent N.P.D.
h m s		h m s	° ' "
1860, Dec. 17	10 0 43.07	3 47 41.70	74 44 34.47
18	9 56 11.64	3 47 6.10	74 45 11.46

Massilia (30).

Mean Solar Time of Observation.		Apparent R.A.	Apparent N.P.D.
h m s		h m s	° ' "
1860, Dec. 18	12 12 0.46	6 3 17.23	67 42 9.87
19	12 7 0.67	6 2 13.18	67 42 19.03
22	11 52 0.94	5 59 0.66	67 42 52.47

Euterpe (27).

Mean Solar Time of Observation.		Apparent R.A.	Apparent N.P.D.
h m s		h m s	° ' "
1860, Dec. 5	7 34 20.41	0 33 36.30	88 29 48.58
6	7 30 54.23	0 34 6.12	88 25 15.89

Amphitrite (39).

Mean Solar Time of Observation.		Apparent R.A.	Apparent N.P.D.
h m s		h m s	° ' "
1860, Dec. 8	9 31 44.57	2 43 9.42	65 1 52.08
18	8 48 22.98	2 39 6.30	65 33 46.62

No occultations of stars by the moon were observed during the month of December 1860.

Occultations and Transits of Jupiter's Satellites.

Day of Observation.	Satellite.	Phenomenon.	Mean Solar Time.				Observer.
			h	m	s		
1800.							
Dec. 18	I.	Tr. egress	12	2	23.86		E.
18	IV.	Occ. disapp. first cont.	12	18	21.26		E.
18	IV.	„ central bis.	12	21	20.76		E.
18	IV.	„ last cont.	12	23	20.44		E.
18	IV.	Occ. reapp. first cont.	17	9	28.47		A. D.
18	IV.	„ central bis.	17	12	3.03		A. D.
18	IV.	„ last cont.	17	14	17.67		A. D.

The initials E. and A. D. are those of Mr. Ellis and Mr. Davis.

On the Lunar Theory. By Sir J. W. Lubbock, Bart.*
(Abstract.)

The memoir is chiefly occupied with the comparison and discussion of the numerical values of the coefficients of the several inequalities, as given by M. Plana and M. de Pontécoulant, and in the *American Tables*, Washington, 1853. It is shown what are the quantities which should be added to the longitudes and latitudes of the *American Tables* in order to obtain those which would be given by the coefficients of Pontécoulant, when quantities under $0''.3$ are neglected; these corrections are so small that, practically, the places given by the *American Tables* may be considered as identical with the places which would be given by tables founded upon Pontécoulant's coefficients, and therefore by the theory of Lubbock and Pontécoulant. The author remarks:—"There is no error in M. Plana's analytical expression for the longitude in terms of the first, second, third, or fourth order. There are three errors of the fifth order, of which one is insensible. In M. Plana's analytical expression for the latitude there are no errors of the first, second, or third order, and only two of the fourth order. By carefully examining M. Plana's numerical reductions, M. de Pontécoulant and myself have succeeded in discovering the causes of the principal differences between M. Plana's coefficients and those of M. de Pontécoulant: there remain discrepancies in terms of the fifth and higher orders which it is very desirable should be got rid of. M. de Pontécoulant and myself, where we differ from M. Plana, went over our calculations so many times that we think the error can hardly be on our side; and unless M. Plana will revise

* The Memoir, which was read at the Meeting in November last, will probably appear *in extenso* in the *Memoirs* of the Society.—Ed.

his work, we must despair of this being ever accomplished : for no one again will ever possess the intimate knowledge which M. Plana has of the indirect method. As it appeared to me that astronomers would view with greater confidence a comparison of places given by the *American Tables* made by persons who could have no interest in enhancing their value, I made application to Mr. Hind, the Superintendent of the *Nautical Almanac* ; and, in consequence, he directed Mr. Farley to procure places of the Moon from the *American Almanac*, and compare them with the observations made at Greenwich for the years 1856, 1857, and 1858 ; and as Mr. Hind has kindly allowed me to publish them with this paper, any one can see at once how extremely accurate the places given by these tables are, and how much more so than those given by Burckhardt's Tables. In these *American Tables* coefficients are employed, with very few exceptions, and those of no moment, founded on our labours—that is, M. Plana's, M. de Pontécoulant's, and my own—and due to theory alone. I am confident, therefore, that a joint posterity will give to us—that is, to Plana, Pontécoulant, and Lubbock, who, in 1846, furnished the means of constructing tables of the moon without any empirical hypotheses—the credit of first bringing the errors of the lunar theory within the errors of observation, and thereby bringing to perfection the solution of the problem of finding the longitude at sea by means of lunar observations.”

The memoir contains an investigation, by means of the equations employed in the author's lunar theory (that is, in which the time is the independent variable), which sustains Prof. Adams' value of the second term ($= \frac{3771}{64} m^4 e'^2$) in the expression for the acceleration. It contains also two examples of the determination of the inequalities of the reciprocal of the radius vector and the longitude.

The President gave a short account to the Meeting of the proceedings at the Radcliffe Observatory since the decease of the late M. J. Johnson, and his own appointment as Radcliffe Observer. Observations were made regularly with both the Meridian Instruments. The photographic registration of meteorological observations had been carried on without any interruption, and with great regularity. Several amendments which were required in the Heliometer had been successfully effected, and the instrument was then in good working order.

On Controlling Clocks by Electricity.

By Charles V. Walker, Esq.

Mr. Charles V. Walker gave a verbal address, which he has since, at the request of the Editor, kindly reduced into writing, as follows :—

“ Mr. President,—You are fully aware—no one more so—that the clocks (certain of them, at least) on the South-Eastern Railway should exhibit very correct time. Over and above their ordinary duty as timekeepers, some of them have special service to perform in behalf of the Royal Observatory, with all of which you are personally very familiar, but which it may be interesting to explain to the Fellows of this Society, in so far as a certain clock in the Telegraph Office of the London Bridge Station is concerned, and which clock is under the immediate control of the prime clock in the Royal Observatory, on which error is not allowed to accumulate. I will first explain the special service required of this clock, and then describe the arrangements by which it is retained under the control of the distant clock in question, and made to show the same time, second by second.

“ For the last ten years a very elaborate system of automatic distribution of time-signals, including the daily drop of a time-ball at Deal, has been in operation on the South-Eastern Railway. As far as I have been concerned, it originated in a conversation between myself and Mr. Glaisher on April 13, 1849, followed by a letter from him on May 10, in which he said, ‘I also wish to talk with you about the laying down a wire from the Observatory to the Lewisham Station.’ The question was taken up with great zeal and activity by the Astronomer Royal, and ere long the necessary agreements between the Admiralty and the Railway Company were executed. The Company very readily fell into our views, and erected four wires between Lewisham Station and London Bridge, charging for them merely the cost price; they charge the Observatory a few shillings annually for maintenance, and a few shillings for rent and right of way—the sums being merely nominal. The Observatory supply the Railway Company with a time-signal every hour, if required, and with other signals every second or two seconds, as necessities may dictate, for driving or controlling clocks. The Royal Observatory and Lewisham Station were connected by four gutta-percha wires, laid under Greenwich Park and across Blackheath. In course of time the buried wires became defective, and, to take their place, wires were suspended in the air, in 1860, from the Observatory to Greenwich Railway Station; and the railway wires were, at the same time, transferred from the North Kent Railway, which leads to Lewisham, to the Greenwich Railway. This route is now used. The first of the four wires is joined at the

London terminus to one of the Electric Telegraph Company's wires, which leads to Lothbury, whence signals are distributed throughout the kingdom; the second is used for controlling the clock that forms the subject of these remarks; the third is for the hourly time-signal on the South-Eastern district; and the fourth is spare.

"The wires along which the time-signals are distributed to the stations on the South-Eastern district are borrowed automatically by the aid of the clock at London, and for the ball-drop at Deal by the further aid of a clock at Ashford. They must be borrowed at the right time, and only for a short time; they cannot be spared long from their ordinary telegraph duties. And for the Deal drop it is further necessary that the borrowed wire shall for the time being be perfectly safe from the ingress of false signals from any of the telegraph stations, the clerks at which might, but for the precautions that have been taken, unwittingly send a speaking signal, and make a false drop at Deal, misleading the captains of ships then lying in the Downs.

"When the system first commenced, a Shepherd's electric clock was erected at the London terminus; it is without weight or spring, and its motive power was supplied, second by second, by the aid of the pendulum at the Royal Observatory, which in its oscillation made contacts with certain light springs, and so directed electric currents of the required character from batteries placed at Greenwich to electro-magnets placed within the clock at London. While the gutta-percha wire was new and in good condition, which was for a considerable time, the London clock would, for weeks, and often for months together, continue to show the same second as the Greenwich clock. We were able to verify this by the hourly time-signals on the other wire, already referred to, and which could be read off on a galvanometer placed inside the clock-case at London. This is a very remarkable illustration of the immunity from interruption that is enjoyed by ordinary telegraphic circuits. The failure of a single current would create an error of two seconds in our clock, and yet week after week true time was shown; so that $60 \times 60 \times 24 = 86400$ currents of electricity passed daily in safety from Greenwich Park to London Bridge. At last the gutta-percha began to succumb to time and other influences, and electricity was lost on the road. At first a solitary current now and then throughout the day failed; matters grew worse, the non-arrivals were more frequent, and our clock not only failed in its special purposes, but ceased to be an ordinary timekeeper, and we had often to cover the dial.

"I determined, in future arrangements, to abandon this bold experiment; for, all things considered, and notwithstanding its first successes, it was a bold experiment to place a distance of six miles between the motive power and the

machine—in this case not a small one—to be moved ; and as we could not well abandon the clock, fitted as it was with all the apparatus for borrowing the telegraph wires at the selected hours for time-signals ; and as we had no convenient place for it, if we had supplied it with the ordinary going power—a weight and a pendulum—I arranged that it should continue to be an electric clock, but should receive the necessary electric currents, second by second, by the aid of a pendulum oscillating in London instead of in the Royal Observatory—the clock to which this pendulum appertains being to be put under the control of the Greenwich clock. The clock selected for this work had originally been an electric clock. I furnished it with a wooden pendulum and a weight, and made other necessary alterations, furnishing it with a dead-beat 'scapement. I availed myself of the electric parts of the clock—at least of such portions of them as served my purpose—leaving them in their original places in the body of the clock, where they were so arranged as to act upon the crutch, and by its means on the pendulum. It will be understood from this that I did not select this mode of controlling a clock in any preference to the admirable method practised by Mr. Jones, of Chester (and adopted by Mr. Hartnup at Liverpool and Mr. Airy at Greenwich), who controls by a bar-magnet and a coil of wire near the lower end of the pendulum ; but having to deal with a clock already possessed of electric parts, I sought out how I might best turn them to account *in situ*. This clock has acquired the name of the 'Mechanico-Electric Clock,' which serves very well as a distinctive name. It contains a U-shaped bar of iron, with its ends upward, and surrounded by coils of No. 16 copper wire ; this wire is $\frac{1}{8}$ in. in diameter. A brass bar is fixed by its centre upon the arbor that carries the crutch ; it is at right-angles to the arbor, and in a horizontal position. Any force applied to this bar moves the arbor ; any force applied to the arbor moves the bar. At one end of the brass bar is a bar of soft iron, at right-angles to the brass bar, and also in a horizontal position ; it in fact forms, with the brass bar, a T-piece. A counterpoise, capable of adjustment, is fitted to the other arm of the brass bar ; the iron bar is situated above and facing the poles of the electro-magnet already described, and is attracted downwards whenever a current of electricity is present in the coils of wire, and, of course, reacts on the pendulum itself by means of the crutch, with which it is solidly connected. The pendulum is tolerably good, and measures very fair time for ordinary purposes. When the clock is set going and left to its own resources, it may vary a few seconds more or less either way during the day. All this time the iron bar or armature approaches to or recedes from the electro-magnet at each alternate oscillation of the pendulum, but is uninfluenced. If, now, from some foreign source, a current of electricity is made to circulate through

the coils at each alternate second, the iron bar, and with it the crutch and the pendulum, are perfectly controlled by these synchronous currents, and the 'mechanico-electric clock' is retained in strict companionship with the clock from which the currents are sent. In the preliminary experiments in the shop, a gaining or a losing rate of twenty or more seconds per hour was put upon the clock; but in either case it was perfectly controlled, and constrained to show the same time as that exhibited by the controlling clock.

"The manner in which the currents are put into circulation by the Observatory clock is simple enough. At London, a wire is led from the earth to one end of a zinc-graphite battery of a few cells; from the other side of the battery a wire goes to the commencement of the coil of the electro-magnet in the clock; from the end of the coil, a wire passes to one side of a galvanometer, fixed on the outer side of the clock-case. I may here mention that this galvanometer forms no necessary part of the system; it is placed here so that the motions of its needle at every alternate second may indicate to those in charge, that the circuits are in order and the currents are duly passing. They can detect also at a glance, by the feeble motion of the needle, when the batteries are getting low. From the other side of the galvanometer, the wire proceeds direct to the Royal Observatory, where it terminates in a slight spring, which is touched by the pendulum at every alternate second. The pendulum, by means of the frame of the clock, to which it is suspended, is connected by a wire to the earth. So that each time the pendulum touches the spring, the telegraph circuit is completed, and the battery current flows. This arrangement has been for several months in operation; and accomplishes all that we had proposed. Week after week, our clock has shown the same second as the clock at Greenwich. The control is effected at a very small expenditure of electric force.

"I have had some experience in the relations that have been established between electricity and time. The conclusions to which I have arrived are, that electricity is out of place as a moving power for clocks. It is an unnecessary refinement; and is far more troublesome than a weight or a spring. But electricity is of very great value as a controlling power. It is an unfortunate circumstance that the pendulums of 8-day dials, of which there are thousands in this country, oscillate in no fraction of a second. There is an established train of wheels; and stereotyped numbers for the wheels and pinions, and these are often intermixed. These dials are the staple time-keepers throughout the country, in offices and places of business. Dozens of them are often found under the same roof. With very little addition to the movement every such group could have been kept in perfect control by the one pendulum of a good regulator, if they were other than they are.

"There is one point in the control of clocks that must not

be overlooked. The same currents that will keep a pendulum that is once in beat always in beat, will also stop the same pendulum altogether, if they arrive at the wrong time; that is, if they arrive so as to oppose its movement. It will not do to establish the electric communication hap-hazard, when the pendulum is at any part of its arc; it must be made to commence so that the motion thus applied to the crutch may coincide or conspire with the then motion of the pendulum. Before erecting the clock, and while it was in the shop, I made many experiments on this point, and invariably stopped the clock, when I applied the current at the wrong time. I advised the Astronomer Royal of this peculiarity, and he made some trials on a clock in the Observatory, which was controlled near the bob, on Mr. Jones's plan; and with the same results. This delayed me for some months in putting my clock to the test of real work; because the wires between London and Greenwich were at that time still in a defective state; and I could not depend upon the regular appearance of currents. I made the trial; but when the currents flagged for a time and then recovered their strength, it happened as often as not that they reappeared at the wrong moment, and the clock was repeatedly stopped; so that I was glad to leave the clock to its own resources until the wires were repaired. Since that time, we have had no recurrence of the interruption save in one instance; when from some cause the Observatory clock was at rest for a short time, and of course ceased to give signals; and when again set in motion, the currents caught our pendulum at the wrong time.

"I have since made a provision against these contingencies; but have not had an opportunity to adjust it, nor, indeed, any occasion to bring it into operation. I have divided the Greenwich wire as it enters the clock, and before it arrives at the galvanometer. A pair of light springs are at the division. When the Greenwich pendulum touches the spring there, this pair of springs must also be in contact, or no current can pass. The springs are pressed together by the pendulum as it oscillates against them; and I have so arranged them that they cannot be pressed together by the pendulum unless it is in that particular position in its arc, when the controlling power is valuable. In no other position therefore, in no unfavourable position of the pendulum can the current enter, and the clock will not be stopped. All that happens is that the error, be it a gain or loss, accumulates till it amounts to two seconds; and then the Greenwich and London pendulums are again in beat together, and continue so."

*Abstract of his latest Results. By Prof. Wolf.**(Translation communicated by Mr. Carrington.)*

Some fine series of observations of Flaugergues, Adams, Arago, and others, have enabled me to fill in previous breaks, and to express in the same unit my Relative numbers (for the abundance of Solar Spots in successive years) for the years from 1749 to 1860. They are as follows:—

1749	63·8	1777	63·0	1805	50·0?	1833	7·5 <i>m</i>
1750	68·2 <i>M</i>	78	94·8	06	30·0?	34	11·4
51	40·9	1779	99·2 <i>M</i>	07	10·0?	35	45·5
52	33·2	1780	72·6	08	2·2	36	96·7
53	23·1	81	67·7	1809	0·8	37	111·0 <i>M</i>
54	13·8	82	33·2	1810	0·0 <i>m</i>	38	82·6
55	6·0 <i>m</i>	83	22·5	11	0·9	1839	68·5
56	8·8	84	4·4 <i>m</i>	12	5·4	1840	51·8
57	30·4	85	18·3	13	13·7	41	29·7
58	38·3	86	60·8	14	20·0?	42	19·5
1759	48·6	87	92·8	15	35·0?	43	8·6
1760	48·9	88	90·6 <i>M</i>	16	45·5 <i>M</i>	44	13·0 <i>m</i>
61	75·0 <i>M</i>	1789	85·4	17	43·5	45	33·0
62	50·6	1790	75·2	18	34·1	46	47·0
63	37·4	91	46·1	1819	22·5	47	79·4
64	34·5	92	52·7?	1820	8·9	48	100·4 <i>M</i>
65	23·0	93	20·7?	21	4·3	1849	95·6
66	17·5 <i>m</i>	94	23·9	22	2·9	1850	64·5
67	33·6	95	16·5	23	1·3 <i>m</i>	51	61·9
68	52·2	96	9·4	24	6·7	52	52·2
1769	85·7 <i>M</i>	97	5·6	25	17·4	53	37·7
1770	79·4	98	2·8 <i>m</i>	26	29·4	54	19·2
71	73·2	1799	5·9	27	39·9	55	6·9
72	49·2	1800	10·1	28	52·5	56	4·2 <i>m</i>
73	39·8	01	30·9?	1829	53·5 <i>M</i>	57	21·6
74	47·6?	02	38·3?	1830	59·1	58	50·9
75	27·5 <i>m</i>	03	50·0?	31	38·8	59	96·4
1776	35·2	1804	70·0? <i>M</i>	1832	22·5	1860	98·6 <i>M</i>

If these numbers are laid down graphically, there results a curve-line consisting of numerous waves. It is unquestionable that the length of these waves is variable, and all the epochs of minimum since the discovery of solar spots are very nearly given by the formula

$$\begin{aligned}
 t_x &= 1732.823 + 11.119 . x \\
 &+ 1.621 . \sin \left(146^\circ + x . \frac{360^\circ}{15} \right) \\
 &+ 1.405 . \sin \left(230^\circ + x . \frac{360^\circ}{5} \right)
 \end{aligned}$$

If the two last variable terms in this formula are neglected, we have the mean epochs of Minimum; and if we compare these with the epochs given by the observations, and with the height of the Maxima expressed by the Relative numbers, we find there is a very remarkable connexion, which the following table places clearly in evidence:—

True Minimum.	True—Mean Minimum.	Diff.	Rel. No. of Max.	Diff.	True Maximum.
1744.5	+0.588	+	68.2		1750.0
1755.7	+0.639	—	75.0	+	1761.5
1766.5	+0.320	—	79.4	+	1770.0
1775.8	—1.449	—	99.2	+	1779.5
1784.8	—3.618	+	90.6	—	1788.5
1798.5	—1.037	+	70.0	—	1804.0
1810.5	—0.156	+	45.5	—	1816.8
1823.2	+1.425	—	53.5	+	1829.5
1833.8	+0.906	—	111.0	+	1837.2
1844.0	—0.013	+	110.4	—	1848.6
1856.2	+1.068		98.6	—	1860.5

The constant opposition of signs can hardly be regarded by any one as accidental, and if admitted to be regular, we have manifestly this law,—*greater activity on the Sun goes with shorter periods, and less with longer periods.* I believe this law to be one of the most important relations among the Solar actions yet discovered, and which, taken in connexion with the results for distribution in heliographical latitude, and corresponding apparent periods of rotation, promises to throw much light on this difficult subject, and perhaps even on the phenomena of Variable Stars.

Zurich, 1861, Jan. 19.

Mr. Carrington wishes to call attention to the question of the determination of the figure of the Sun, and suggests the measurement for this purpose of photographic pictures of the disk. By aid of a reference given by Mr. Carrington, the Editor has found as follows:—

The question is discussed in a memoir by Mossotti, "Formole per determinare gli Assi del Sole supposto uno spheroide ellittico, con applicazioni," in the Appendix to the Milan Ephemeris for 1820. The figure is in the first instance assumed to be an ellipsoid with three unequal axes, but supposing it to be a spheroid of revolution the formulæ are as follows: (for greater convenience D_v , D_h are written in the place of the single quantity D' , which is used in the memoir to denote successively the vertical and horizontal semi-diameters):

D denotes the equatoreal diameter as it would be seen at the mean distance 1; D_v and D_h the vertical and horizontal diameters reduced to the mean distance 1; e the excentricity of the spheroid ($= 1 - \frac{c^2}{a^2}$ if a , c , are the equatoreal and polar semi-diameters). Then

$$D - D_v = \frac{1}{2} e^2 D p^2, \quad D - D_h = \frac{1}{2} e^2 D p_1^2,$$

and consequently

$$\frac{D_v}{D_h} = \frac{1 - \frac{1}{2} e^2 p^2}{1 - \frac{1}{2} e^2 p_1^2},$$

or

$$D_h - D_v = \frac{1}{2} e^2 (p^2 D_h - p_1^2 D_v),$$

in which last formulæ, it would clearly be unnecessary to reduce the observed diameters to the mean distance 1, since the formulæ contain only the ratio of these diameters. The values of p^2 , p_1^2 , are calculated by the formulæ in the memoir with the data

Inclination of the solar to the terrestrial equator = $25^\circ 40'$,
Right ascension of ascending node, ditto ditto = $16^\circ 50'$,

for the middle of each month; viz., the values are

	p^2	p_1^2
January	0.99	0.00
February	0.91	0.07
March	0.82	0.16
April	0.81	0.18
May	0.88	0.12
June	0.97	0.03
July	0.99	0.00
August	0.92	0.06
September	0.83	0.16
October	0.81	0.19
November	0.88	0.12
December	0.97	0.03

The observations of Littrow and Maskelyne referred to in the memoir make the figure a prolate spheroid; those of Carlini, an oblate spheroid.

In a paper in the *Ast. Nach.* t. ix. p. 365 (1831), M. Bianchi has applied the above formulæ to observations taken at Modena in the years 1828 and 1829: the figure is found to be an oblate spheroid; but the vertical diameters alone, the horizontal diameters alone, and the two conjointly, give for $\frac{1}{2} e^2$ the very discordant values $\frac{1}{1925}$, $\frac{1}{110}$, $\frac{1}{249}$. As to the deduction of the true ellipticity from the observed figure of the disk, see also Mr. Grant's "Note on the correction to be applied to the apparent ellipticity of a Planet, in consequence of the elevation of the Earth above the plane of the Planet's Equator," *Monthly Notices*, vol. xiii. (1853), pp. 192-196.

RECENT PUBLICATIONS.

Théorie du Mouvement de la Lune. Par M. Delaunay (premier volume) being t. xxviii. of the *Mém. de l'Acad. de Paris*.

The following is in substance the account of the work as given by the author in the *Comptes Rendus* (séance du 24 Déc. 1860):—

"I have already had occasion to explain the object of the great work which I undertook fourteen years ago on the theory of the Moon. It is known that my end was to effect a new analytical determination of the lunar inequalities carrying the approximations notably further than had been done before me. Concentrating at first all my efforts on the inequalities due to the disturbing force of the Sun, and admitting in the calculation that the motion of the Sun takes place according to the laws of elliptic motion, I proposed to myself to investigate all the parts of these inequalities which are not of an order superior to the seventh. M. Plana, in his great work on the Lunar Theory, had stopped at the inequalities of the fifth order. The method employed by me consists in a series of operations similar to each other, whereof each has for its object to get rid of one of the periodic terms of the disturbing function by the aid of a simple change of variables. When, by the application of this method, we have removed from the disturbing function the terms of most importance in regard to the magnitude of the inequalities to which they give rise, the question is simplified, and can then be treated as easily as if it related to the inequalities of a Planet or the Sun.

"The volume which is just printed contains a part of the formulæ which I have obtained by operating in conformity with the above method. It is composed of five Chapters. The first is devoted to the establishment of the differential equations, the integration whereof gives the inequalities of the motion of

the Moon; the second, to the development of the disturbing function and of the elliptic values of the Moon's co-ordinates; and the third, to the exposition of the analytical method which I have imagined for integrating the differential equations by dividing the work so as to enable the further development of the approximations in each part. These three Chapters, much less extensive than the others, furnish a kind of introduction to the actual working out of the method, which is developed in the following chapters. The fourth Chapter contains the complete development of the disturbing function, with the different modifications it has successively undergone by means of a succession of 57 operations effected upon it to disembarass it of the most important terms; this development contains 460 terms. Lastly, the fifth Chapter contains all the details of the establishment of the formulæ relative to the 57 operations in question. The second volume, the printing of which I hope to commence forthwith, will contain, 1°, the different formulæ intended for taking account of the terms which remain in the disturbing function after the foregoing 57 operations have been effected; 2°, the expressions of the three co-ordinates of the Moon with *all* their inequalities to the seventh order inclusive for the longitude and the latitude, and to the fifth order for the reciprocal of the radius vector; 3°, lastly, several chapters intended to complete the expressions for the co-ordinates of the Moon by taking account of all that was provisionally neglected in order to the consideration of only the capital part of the question. Desiring that my work should inspire to astronomers as much confidence as possible, I have neglected none of the means which appeared to me proper for facilitating the verifications which may occur to any of them. In particular I may refer to the indications accompanying the different parts of the disturbing function (Chap. IV.), and which have for their object to show the origin of each part.

"The simplicity and regularity of the method which I have followed, for the inequalities of the Moon's motion, have permitted me to set forth the series of the operations with all desirable clearness, without the necessity of long explanations. Thus, the last two chapters of my first volume, which occupy seven-eighths of the entire volume, consist almost exclusively of formulæ, with very little text. Many of the formulæ are very long; in particular that which forms the whole of Chapter IV., and which covers 138 pages. The printing of the volume presented the greatest difficulties, and it has required all the skill and zeal of M. Bailleul, the Director of the Mathematical Printing Establishment of M. Mallet-Bachelier, to bring the work to a conclusion, and to render all the parts of the volume agreeable to the eye without injury to the perfect clearness of the formulæ."

The Radcliffe Catalogue of 6317 Stars, chiefly Circumpolar, reduced to the epoch 1845^o, formed from the Observations made at the Radcliffe Observatory under the Superintendence of Manuel John Johnson, M.A., late Radcliffe Observer. With Introduction by the Rev. Robert Main, M.A., Radcliffe Observer. Published by order of the Radcliffe Trustees. 8vo. Oxford, 1860.

The following are extracts from Mr. Main's Introduction :

"The Radcliffe Catalogue of stars contains the result of *all* the Star-observing at the Radcliffe Observatory from 1840 to the end of the year 1853. For the year 1854 only Fundamental Stars are included, and those which were necessary to make more complete the re-observation of Groombridge's Catalogue of Circumpolar Stars; and for the following years as far as 1859, in general such observations only were used as were necessary in order to complete the results of former years for the Stars already included in the Catalogue.

"The compilation of the Catalogue was commenced as early as the year 1850; and at the time of the death of Mr. Johnson the whole of the work was in the hands of the printer, and a few sheets were actually printed off under his superintendence. After his decease the printing of the remainder of the Catalogue went on without serious interruption until its completion, under the superintendence of Mr. Quirling, the First Assistant of the Observatory.

"The chief labour of the comparison of the proofs with the manuscript was performed by Mr. Luff, of whose most valuable and almost gratuitous labours mention is so frequently made by Mr. Johnson in the introductions to separate volumes of the Radcliffe Observations.

"The MSS. used in the compilation of the Catalogue have been with few exceptions bound up and labelled, and they admit of very easy reference.

"On the whole, . . . the equinox employed is that of the *Nautical Almanac* for 1840, without any attempt at independent determination by observations of the Sun.

"The result [of a comparison given in the introduction] is so far satisfactory as showing that the equinox to which the Right Ascensions of the Radcliffe Catalogue have been referred does not differ materially from that of the Greenwich Twelve-year Catalogue; but there is a variation in the differences of Right Ascension for different hours, which is too well marked to be accidental, and of which I am unable to give any account. From x^h to xv^h , namely, the mean of the difference is $0^s.09$, while the mean for the remaining hours is only $0^s.025$.

"There is no doubt but that this anomaly depends on something which has affected the Radcliffe observations or their process of reduction, because similar differences are found to

exist in the mean Right Ascensions of the Fundamental Stars as deduced by *Wolfers* for the year 1860, as compared with Johnson's results from the observations of 1854 and 1855 reduced to 1860, as given in the sixteenth volume of the Radcliffe Observations. Still the origin of it is very obscure, and after thinking of many possible causes I do not find one which is altogether adequate. It may be, however, remarked that the hours of Right Ascension for which the differences are greatest, are those which correspond to the Spring and early Summer months for evening observations of the stars in those hours.

"As the principal object which Mr. Johnson had in view in star-observing was the complete re-observation of the stars in Groombridge's Catalogue, all in that Catalogue have been looked for with great care, and with very few exceptions all have been re-observed.

"In consequence of the lamented death of Mr. Johnson, the publication of the Radcliffe Catalogue has been delayed considerably beyond the time which would have been necessary if he had been spared to see the printing of the work completed. In fact, the printing was completed about the middle of last year [1859], and has waited only for the introduction and general revision, which could be performed only by a person authorised to assume the direction of the Observatory. On my appointment to the office of Director in June last, the study of the details of the computations was one of my earliest cares; and I did not rest satisfied till I had convinced myself, by a searching scrutiny, of the accuracy of all the elements and of all the processes employed, and had put myself into a position enabling me to hold myself responsible for the general accuracy of the work. I found, however, that it would not be prudent to proceed to the publication of it until I had come into residence; and since that time, or from October 1st [1860], I have been employed upon it as incessantly as my other duties permitted; and I now confidently offer it to the world as a work well sustaining the reputation of the late Director, and as one of the most important and accurate of modern Star Catalogues."

Catalogo di 1321 Stelle Doppie misurate col grande Equatoriale de Merz, osservate all' Osservatorio del Collegio Romano, e comparate colle Misure anteriori. Del P. A. Secchi. Roma, 1860.

An account of the work is given by the author in the *Comptes Rendus*, t. li., (17 Dec. 1860). The work is the fruit of the observations of five years. It contains the measures of 1321 Double and Multiple Stars, made with the great equatorial of Merz, and compared with the anterior measures of

Struve, Mädler, and other astronomers for the determination of the motions.

The following are some of the conclusions from this review of nearly 7600 complete observations of stellar systems :

1°. The number of Stars in the first four orders of Struve, the motion of which is established, is to the total number of Stars observed in the following proportion :

Order 1, stars in motion, to all the observed stars, as 1 : 2			
.. 2	..	..	1 : 3
.. 3	..	..	1 : 6
.. 4	..	..	1 : 12

The review of these four orders comprises all the *Lucidæ* and a great part of the *Reliquæ* of the *Mensuræ* of Struve; it embraces also a large number of the stars of the catalogues of Pulkova, of Herschel at the Cape of Good Hope, of Smyth, &c.

2°. As it is important to fix the attention of astronomers on the stars the motion of which is ascertained, in order to the perfecting of the observations, and the avoidance of a loss of time in the measurements of fixed objects, there is given at the end of the Catalogue a recapitulation of the Stars measured, distinguishing them into the classes of certain motion, of doubtful motion, or of no motion. Denoting them by Struve's numbers, the Stars of certain motion are,

First order.

L. Nos.	2	13	73	205	216	257	333	412	460	511	1356	1457
	1670	1728	1819	1937	1938	1967	2055	2084	2215	1315	2438	2509
	2574	2729	3062.									
R.	234	236	278	340	1426	1457	1663	2402.				

Second order.

L. Nos.	113	138	186	228	262	305	314	400	408	535	566	577
	945	948	1037	1126	1157	1187	1196	1338	1348	1476	1517	1523
	1555	1647	1687	1768	1781	1865	1883	1932	1944	1998	2032	2107
	2114	2171	2281	2289	2369	2437	2525	2579	2744	2799	2881.	
R.	183	208	498	1081	1757	1837	1876	2106	2356	2434	2491	2544
	2662	2856	2934	3047.								

Third order.

R. Nos. 91 202 389 572 742 997 1273 1424 1536 1777 1785 1788
 1909 1954 1988 2021 2052 2130 2382 2383 2576 2603 2624 2644
 2804 2909 3001 3050.
 158 195 249 355 403 932 1439 1450 1658 1722 1842 2026
 2097 2120 2205 2303 2309 2484 2541 2828 2900 2942 3046.

Fourth order.

L. Nos. 422 589 982 1066 1110 1263 1306 1543 1888 2272 2725 2822
 2928 2944 3008.
 R. 44 122 295 1300 1830 1925 2165 2455 2538 2877 2976.

Fifth order.

60 550 668 1516 2732 2708. — 2220 2262 142.

These numbers include all the Stars the orbital motion whereof is known. But in order to decide as to many others, in particular of the *doubtful* ones, it will be necessary to wait another quarter of a century, the interval which separates these from the observations of M. Struve. The author proposes to continue his observations on the doubtful class, and for the more distant orders, the review whereof is still imperfect.

Mémoire sur la Détermination des Distances polaires des Etoiles Fondamentales. Par E. Laugier, Membre de l'Institut, Astronome adjoint du Bureau des Longitudes, &c. (forms part of t. xxvii. of the *Mémoires de l'Acad. des Sciences*), Paris, 1859.

The observations were made at the Paris Observatory in the years 1851–1853, with the Mural Circle of Gambey. The memoir is divided into two parts; the first contains, 1°, the description of the Mural Circle; 2°, the series of rough observations made by the author with the instrument; they are collected in tables placed at the end of the text; 3°, all the necessary details in regard to the instrumental corrections to be applied to the observations and in regard to the elements of reduction; 4°, the determination of the colatitude of the Mural Circle and of the polar distances of the observed Stars.

In the second part the author discusses the declinations of 140 stars, published in the different Catalogues, and he deduces a normal Catalogue with which he compares the others. Lastly, starting from the normal declinations he determines anew the colatitude of the Mural Circle by means of the zenith distances given in the first section.

The epoch of the normal polar distances is January 1, 1852. The colatitude, as deduced from the Circumpolar Stars, is $41^{\circ} 9' 48''.66 \pm 0''.05$, and as deduced from the normal positions and zenith distances of the Fundamental Stars is $41^{\circ} 9' 48''.72 \pm 0''.04$.

Posizioni Medie de 2706 Stelle pel 1° Gennajo 1860 distribuite nella Zona Compresa fra 10° et $12^{\circ} 20'$ de Declinazione Australe dedotte delle Osservazione fatte negli Anni 1856-57-58, nell' I. R. Osservatorio di Padova. Memoria di Giovanni Santini. 4°, Venezia, 1858. (Estr. dal volume vii. delle Memorie dell' I. R. Istituto Veneto.)

The memoir is a sequel to two others published in vols. v. and vi. of the *Nuovi Saggi dell' Accademia di Padova*, containing a catalogue of stars between the parallels of 10° north declination and 10° south declination. The epoch of the catalogue is, as stated, in the title, Jan. 1, 1860. The right ascensions and declinations of the observed stars are compared with those in the catalogue of Weiss.

Sur les Lois du Mouvement propre des Etoiles du Catalogue de Bradley. Par M. Kowalski. 8vo. pp. 1-90, 1859.

The object of the memoir is to investigate whether the proper motions, and consequently the true motions in space, of the Stars of Bradley's Catalogue, are subjected to any other laws than those which follow from the motion of the planetary system, and what consequences can be deduced from them with reference to the structure of the Stellar Universe and the forces which govern it. The results deduced by M. Mädler from the proper motions of the stars in the Catalogue in question serve as the basis of the investigations of the memoir. The Catalogue of Bradley contains 3222 stars; of these there are only 86 the proper motions of which are not known, and the materials are thus furnished by 3136 stars. The conclusions arrived at are not stated so explicitly, as that, without risk of misrepresentation, a *résumé* of them can be given, but the memoir will probably be read with interest by those who have occupied themselves with the speculations of Stellar Astronomy.

Note relative à une Courbe du Sixième Degré qui se présente en Astronomie. Par E. de Jonquières. Tortolini, t. i. pp. 112-116. (1858.)

The formula for the Equation of Time, as a function of the true longitude of the Sun, was put by Lagrange in the form —

$$E = -462 \sin(\phi - \alpha) - 593 \sin 2\phi - 3 \sin 2(\phi - \alpha) + 13 \sin 4\phi,$$

where ϕ is the longitude of the sun, α that of the aphelion [? apogee], and E is given in seconds of time.

Neglecting the last two terms, which are of comparatively small magnitude, and putting $\frac{1}{2} \frac{E}{593} = \epsilon$, $\frac{231}{593} \sin \alpha = a$, $\frac{231}{593} \cos \alpha = b$, this gives the equation

$$\epsilon = a \cos \phi - b \sin \phi - \sin \phi \cos \phi,$$

which may be considered as the polar equation of a curve, the radius vector whereof is proportional to the equation of time.

The note belongs, not to Astronomy, but to Modern Geometry, and contains a very interesting discussion, from that point of view, of the properties of the above-mentioned curve; but the figure of the curve, in which the radius vector gives the value of the equation of time on the scale of one minute of time to a centimetre of length, shows very distinctly the march of the equation of time throughout the year. The curve consists of four loops of unequal magnitudes, giving, therefore, a quadruple point at the origin; but, besides this, the largest loop (which corresponds to the months September to December) overlaps the two adjacent loops, so that there are two double points, one on each axis. The figure might with great propriety be introduced into elementary treatises of Astronomy.

Among the presents to the Society were two handsomely bound manuscript volumes, in folio, containing Logarithms and other Mathematical Tables by the late Thomas Wright Hill, F.R.A.S.; and, in particular, Computations for a Table of Logarithms to 23 places, whereof 21 or 22 will be accurate for all composite numbers from 1 to 220000, originally commenced to 17 places for 15 true places, and now afterwards extended to the 23 places.

The volumes were presented by the author's son, Matthew Davenport Hill, Q.C.

ERRATA.

- P. 52, lines 3, 4, 6. The power should be 474 instead of 174, the diameter of the field of view 5'.68 instead of 5".68, and the major axis of the nebula 89" instead of 89'.

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MONTHLY NOTICES
OF THE
ROYAL ASTRONOMICAL SOCIETY.

VOL. XXI.

Feb. 8, 1861.

No. 4.

THE Annual General Meeting of the Society, Rev. R. MAIN, President, in the Chair.

**Edward Brailsford Bright, Esq., 2 Exchange Buildings,
Liverpool;
Joseph Beck, Esq., Coleman Street;
Richard Inwards, Esq., 18 Albert Street, Camden Road;
James Symmers, Esq., Dollar;
Rev. Edward Frimstone, Winchester;
Samuel Mason, Esq., Redhill, Reigate; and
Joseph Bonomi, Esq., 5 A Portsdown Road, Maida Hill,
were balloted for and duly elected Fellows of the Society.**

**At the Meeting in January, James Lees Kenworthy, Esq.,
The Park, Ealing, was balloted for and duly elected a Fellow
of the Society.**

***Report of the Council to the Forty-first Annual General
Meeting of the Society.***

**The year on which the Council now report has not, perhaps,
been marked by any occurrence of the first order of importance.**

Nevertheless, it will be found to have done its part towards the progress of the science; those useful labours which are always preparing great results have been sedulously pursued.

The Report of the Auditors, subjoined, will show the state of the finances :—

RECEIPTS.

	£	s.	d.
Balance of last year's account	264	15	7
By dividend on £1900 Consols ..	26	19	2
By ditto on £3500 new 3 per Cents	101	14	5
By ditto on £2000 Consols	28	15	0
By cash of East India Government	75	0	0
On account of arrears of contributions	111	6	0
128 contributions (1860-61)	268	16	0
7 compositions	147	0	0
21 admission-fees	44	2	0
14 first year's contributions	26	5	0
2 contributions for 1862	4	4	0
1 contribution overpaid (to 1862)	1	1	0
Sale of Publications	67	5	0
	<u>£1167</u>	<u>3</u>	<u>2</u>

EXPENDITURE.

Salaries:—	£	s.	d.	£	s.	d.
Mr. Cayley, 1 year as Editor of the Society's Publications	60	0	0			
Mr. Williams, 1 year as Assistant-Secretary	100	0	0			
Ditto commission on collecting £522 19s.	26	3	0			
				186	3	0
Investments:—						
Investing £100 3 per Cent Consols	94	7	6			
Taxes:—						
Property Tax, 1 year	1	17	6			
Assessed and Land, ditto.....	3	2	6			
				5	0	0
Bills:—						
J. Basire, engraver.....	3	1	3			
Troughton and Simms	5	17	0			
Geo. Barclay, printer.....	355	6	0			
Strangeways and Co., printers.....	75	6	6			
Smith and Co., engravers	4	2	6			
Malby and Son, lithographers	14	15	0			
J. Rumfit, bookbinder	7	11	0			
J. Taylor, matting.....	3	15	9			
Willis, dinner.....	3	10	0			
Mrs. Jones (Lee Fund).....	3	5	6			
				476	10	6
Carried forward.....	£762	1	0			

	£	s.	d.
Brought forward	762	1	0
Miscellaneous items:—			
Charges on books, and carriage of parcels ...	4	13	9
Postage of <i>Monthly Notices</i> , letters, &c.	42	8	0
Porter's and charwoman's work	23	18	9
Tea, sugar, biscuits, &c. for evening meetings	13	13	0
Waiters attending meetings	3	17	0
Coals, &c.	12	0	0
Sundry disbursements by the Treasurer	26	1	8
Sundry payments out of Turnor Fund	1	9	6
Deduction on country cheque	0	1	3
		128	2 11
Balance at Banker's	276	19	3
	<u>£1167</u>	<u>3</u>	<u>2</u>

Assets and present property of the Society, Feb. 8, 1861:—

	£	s.	d.
Balance at Banker's	276	19	3
4 contributions of 3 years' standing	25	4	0
21 ——— of 2 ditto	88	4	0
17 ——— of 1 ditto	35	14	0
On account of arrears	6	0	0
		152	2 0
Due for publications of the Society	.1	9	0
£3500 new 3 per Cents.			
£2000 Consols (including the Lee Fund).			
Unsold publications of the Society.			
Various astronomical instruments, books, prints, &c.			
Balance of Turnor Fund (included in Treasurer's account) ...	45	3	4

The Fellows will doubtless remark that the expenses of printing have increased to an extent which, unless some measures of retrenchment be adopted, may soon lead to a diminution of the capital of the Society. The new Council will, beyond a doubt, give this matter the most serious consideration. Since there can be no doubt that the quantity which may be printed with advantage to the cause will increase, and not diminish, it is clear that the savings of the Society must not be permanently relied on, beyond the income they produce. Hitherto, there has been found no necessity to refuse printed circulation to any matter of even moderate importance, but it is to be feared that the time is near at hand when, unless the Society should continue rapidly to increase in numbers, communications of real value must be either rejected or prejudicially abridged. The Council think it right to make this communication at the earliest moment, and while it is a matter of prediction, not of experience.

Stock of volumes of the *Memoirs* :—

Vol.	Total.	Vol.	Total.	Vol.	Total.
I. Part 1	27	IX.	193	XXI. Part 1 (separate).	204
I. Part 2	69	X.	205	XXI. Part 2 (separate).	100
II. Part 1	86	XI.	216	XXI. (together).	122
II. Part 2	51	XII.	222	XXII.	217
III. Part 1	111	XIII.	240	XXIII.	217
III. Part 2	130	XIV.	223	XXIV.	229
IV. Part 1	126	XV.	207	XXV.	235
IV. Part 2	159	XVI.	223	XXVI.	251
V.	159	XVII.	207	XXVII.	510
VI.	179	XVIII.	207	XXVIII.	478
VII.	202	XIX.	220		
VIII.	188	XX.	216		

Progress and present state of the Society :—

	Compounders.	Annual Contributors.	Non-residents.	Patrons, and Honorary.	Total Fellows.	Associates.	Grand Total.
February 1860 ...	155	193	32	4	384	51	435
Since elected	8	21	...	...	...	...	...
Deceased	—3	—3	—1	...	...	...	...
Resigned	...	—1	...	...	...	...	...
Removal	1	—2	...	...	...	...	...
Name removed for non-payment of admission fee, &c. }	...	—1	...	...	...	...	...
February 1861 ...	161	207	31	4	403	51	454

The instruments belonging to the Society are as follows :—

The *Harrison* clock,
The *Owen* portable circle,
The *Beaufoy* circle,
The *Beaufoy* transit,
The *Herschelian* 7-foot telescope,
The *Greig* universal instrument,

The *Smeaton* equatorial,
 The *Cavendish* apparatus,
 The 7-foot Gregorian telescope (late Mr. Shearman's),
 The Variation transit (late Mr. Shearman's),
 The Universal quadrant by Abraham Sharp,
 The *Fuller* theodolite,
 The Standard scale,
 The *Beaufoy* clock,
 The *Wollaston* telescope,
 The *Lee* circle.

The *Sheepshanks'* collection of instruments, viz.,—

1. 30-inch transit, by Simms, with level and two iron stands.
2. 6-inch transit theodolite, with circles divided on silver; reading microscopes, both for altitude and azimuth; cross and siding levels; magnetic needle; plumbline; portable clamping foot and tripod stand.
3. 4 $\frac{1}{2}$ -inch achromatic telescope, about 5 feet 6 inches focal length; finder, rack motion; double-image micrometer; object-glass micrometer; two other micrometers; one terrestrial and ten astronomical eyepieces, applied by means of two adapters.
4. 3 $\frac{1}{2}$ -inch achromatic telescope, with equatorial stand; double-image micrometer; one terrestrial and three astronomical eyepieces.
5. 2 $\frac{1}{2}$ -inch achromatic telescope, with stand; one terrestrial and three astronomical eyepieces.
6. 2 $\frac{1}{4}$ -inch achromatic telescope, about 30 inches focus; one terrestrial and four astronomical eyepieces.
7. 2-foot navy telescope.
8. 45-inch transit instrument, with iron stand, and also Y's for fixing to stone piers; two axis levels.
9. Repeating theodolite, by Ertel, with folding tripod stand.
10. 8-inch pillar-sextant, divided on platinum, with counterpoise stand and horizon roof.
11. Portable zenith instrument, with detached micrometer and eyepiece.
12. 18-inch Borda's repeating circle, by Troughton.
13. 8-inch vertical repeating circle, with diagonal telescope, by Troughton and Simms.
14. A set of surveying instruments, consisting of a 12-inch theodolite for horizontal angles only, with extra pair of parallel plates; tripod staff; in which the telescope tube is packed; repeating table; level collimator, with micrometer eyepiece; and Troughton's levelling staff.
15. Level collimator, plain diaphragm.
16. 10-inch reflecting circle, by Troughton, with counterpoise stand; artificial horizon, with metallic roof; two tripod stands, one with table for artificial horizon.

17. Hassler's reflecting circle, by Troughton, with counterpoise stand.
18. 6-inch reflecting circle, by Troughton, with two counterpoise stands, one with artificial horizon.
19. 5-inch reflecting circle, by Lenoir.
20. Reflecting circle, by Jecker, of Paris.
21. Box sextant and 3-inch plane artificial horizon.
22. Prismatic compass.
23. Mountain barometer.
24. Prismatic compass.
25. 5-inch compass.
26. Dipping needle.
27. Intensity needle.
28. Ditto ditto.
29. Box of magnetic apparatus.
30. Hassler's reflecting circle, with artificial horizon roof.
31. Box sextant and 2½-inch glass plane artificial horizon.
32. Plane speculum artificial horizon and stand.
33. 2½-inch circular level horizon, by Dollond.
34. Artificial horizon roof and trough.
35. Set of drawing instruments, consisting of 6-inch circular protractor; common ditto; 2-foot plotting scale; two beam compasses and small T square.
36. A pentagraph.
37. A noddly.
38. A small Galilean telescope, with the object lens of rock-crystal.
39. Six levels, various.
40. 18-inch celestial globe.
41. Varley stand for telescope.
42. Thermometer.

These are now in the apartments of the Society, with the exception of the following, which are lent, during the pleasure of the Council, to the several parties under mentioned, viz. :—

The *Wollaston* telescope, to Mr. Rees.

The *Lee* circle, to Mr. Burr.

The *Beaufoy* clock, to Dr. Booth.

The *Sheepshanks* instrument, No. 1, to Mr. Lassell.

Ditto	ditto	No. 2, to Mr. De La Rue.
Ditto	ditto	No. 3, to Rev. C. Pritchard.
Ditto	ditto	No. 4, to Mr. Carrington.
Ditto	ditto	No. 5, to Mr. Birt.
Ditto	ditto	No. 6, to Rev. J. Cape.
Ditto	ditto	No. 8, to Prof. Wheatstone.
Ditto	ditto	No. 19, to Mr. Dayman.
Ditto	ditto	No. 25, to ditto.

The *Sheepshanks* instrument, No. 41, to Rev. C. Pritchard.
 Ditto ditto No. 10, to Rev. C. Pritchard.
 The double-image micrometer, to Mr. Hodgson.
 The *Sheepshanks* instrument, No. 23, to Mr. Spottiswoode.
 The 6-inch circular protractor, to Mr. Birt.

Nothing definite has yet been ascertained respecting the other *Beaufoy* clock, the two invariable pendulums, and the quadrant (said to have been *Lacaille's*), reported for many years past as being in the possession of the Royal Society.

A telescope belonging to the late Rev. R. Sheepshanks, found in the stock of Mr. Simms, has been added to the collection by Miss Sheepshanks.

The Council have awarded the Gold Medal to M. Goldschmidt of Paris, for his astronomical labours, especially for those which have resulted in the discovery of 13 of the Minor Planets. The President will explain the grounds of this award before the Meeting closes.

The twenty-ninth volume of the *Memoirs* of the Society has almost the whole of it passed through the press, and will shortly be ready for publication. It contains more than the usual number of papers, some of them of great importance. The first is a paper by the Astronomer Royal, giving the corrections of the elements of the Moon's orbit, deduced from the lunar observations made at the Royal Observatory at Greenwich from 1750 to 1851; being the extension of a preceding memoir based upon the observations from 1750 to 1830. The year 1851 was fixed on as the definitive limit of the reductions, partly by reason that the date of publication of Mr. Adams's researches on the lunar parallax enabled the use of a corrected parallax in the daily reductions from the beginning of 1852, partly because it was known that Prof. Hansen's tables were advancing, and would probably be ready for adoption in the *Nautical Almanac* at no distant time. The Council cannot but congratulate the Fellows of the Society on the publication in their *Memoirs* of a paper containing the completion of the results deduced from such a series of observations.

Captain Clark has contributed a memoir on the Figure of the Earth, undertaken in reference to the investigations in General T. F. de Schubert's "*Essai d'une Détermination de la véritable Figure de la Terre.*" Whatever the real figure of the Earth may be, if in the investigation it is taken to be an ellipsoid, it is clear that the arithmetical process must bring out an ellipsoid of some kind or other, agreeing better with all the observed latitudes, as a whole, than any spheroid of revolution will do. And although it cannot be said that the Earth is thereby *proved* not to be a spheroid of revolution—

the data being in fact insufficient for this purpose—it is in the meantime interesting to ascertain what ellipsoid does actually best represent the existing measurements. This investigation is accordingly undertaken in the memoir, and the dimensions of the axes, and position in longitude of the equatoreal major axis, together with the probable errors of these quantities, are obtained; it appears, however, from the magnitude of the probable errors that the data are not sufficient to bring out the excentricity of the equator with anything like certainty.

Mr. William Ellis has contributed a paper on the Periodical Variations of Level and Azimuth of the Transit Circle at the Royal Observatory, Greenwich. The tables and diagrams bring out very clearly the character of the periodical variations, depending chiefly on the temperature, to which the instrument is subject.

Sir Thomas Maclear has communicated the Observations of Donati's Comet, made at the Royal Observatory, Cape of Good Hope, between October 11th, 1858, and March 14th, 1859. Observations for orbit were the primary consideration, and two series were made, one by Mr. Mann, with the 8½-foot equatoreal, comprising the whole interval of visibility, the other with the 46-inch telescope by the Director himself and G. W. H. Maclear conjointly, in October and November as long as the observations with that instrument were practicable.

Lord Wrottesley has communicated a Catalogue of the Positions and Distances of 398 Double Stars; the result of observations made at the Observatory at Wrottesley by his assistants, Messrs. Simms, Philpot, and Frederick Morton, but the far greater part of them since the beginning of the year 1854 by Mr. Frederick Morton. The working catalogue of stars for observation was selected from Struve's great catalogue of 1837; and contained, 1°, stars confessedly binary; 2°, others of which there was strong presumptive evidence of their being so; 3°, stars of which the observations by different observers gave anomalous or discordant results. As these objects were worked out, more were added from time to time from among the finer and closer of the double stars, and from those which had only been observed at one epoch; some of these latter exhibit orbital motion.

The President has contributed a paper on the Value of the Constant of Aberration, as deduced from Eight Years' Observations of γ *Draconis*, made with the Reflex Zenith Tube, at the Royal Observatory, Greenwich, which may be considered as a supplement to his paper in the twenty-fourth volume of the *Memoirs*, on the Values of the Constants of Aberration and Nutation, as deduced from the observations of the same star with the 25-foot zenith-tube, dismounted in the year 1842. The resulting value of the constant of aberration is very nearly 20".34, and the author considers that considerable credit is due to this determination. There is, however, as in the former series

of observations, a negative value of the parallax; being in the present series $-0''.24$, which is ten times as great as the probable error, and is therefore an indication of something having affected the observations injuriously, although not to so large an amount as in the case of the 25-foot zenith-tube.

Mr. Cayley has contributed two papers. The first of them, *Tables of Developments of Functions in the Theory of Elliptic Motion*, contains the developments in multiple cosines and sines of the mean anomaly as far as e^7 , of certain powers of the elliptic quotient $\frac{r}{a}$, or of its variable part $(\frac{r}{a} - 1)$, multiplied in either case by a cosine or sine of a multiple of the true anomaly. The tables are based upon a formula given by M. Le Verrier, and were calculated under Mr. Cayley's superintendence, by Messrs. Creedy and Davis, by aid of a grant from the Donation Fund at the disposal of the Council of the Royal Society.

The second of the two papers is on the *Rotation of a Solid Body*, and contains an investigation of the formulæ for the variation of the elements in the disturbed motion, by a method similar to that employed in the author's memoir on the *Theory of Disturbed Elliptic Motion*, published in the twenty-seventh volume of the *Memoirs*. The author calls attention in the paper to the employment of the quantity g varying uniformly with the time but used as an element, and which corresponds to the mean anomaly in the theory of elliptic motion.

The volume contains also a paper by Mr. Spottiswoode, on a *Method of Determining Longitude by means of Observations of the Moon's greatest Altitude*; intended to suggest a method whereby at certain parts of the Moon's orbit and under favourable circumstances, the longitude may be obtained by means of a simple sextant observation. Although not so accurate as some others already in use, and restricted as to the times at which it is applicable, it was thought that a method in which both observation and calculation are simple, might not be without use either as supplementary to more elaborate processes, or as a substitute for them when they are not practicable, and the method in the memoir is suggested in that view.

The concluding paper in the volume is one by Mr. Carington, on the *Distribution of the Perihelia of the Parabolic and Hyperbolic Comets in relation to the Motion of the Solar System in Space*. If the Solar System be moving in the direction from α *Columbæ* to π and μ *Herculis*, there ought then, if such Comets are chance visitors, to be an excess of perihelia in the hemisphere of which α *Columbæ* is the pole, or computing for each orbit the angle between α *Columbæ* and the perihelion, the mean of these angles should be less than 90° . It appears, however, by the tables which are given, that the mean of the angles for the 133 orbits considered is in fact $95^\circ 36'$; the author remarks that this is a result which superior evidence compels us to regard as

nugatory and vitiated by uncontrolled conditions, among which the principal is probably the unequal distribution of observers in the northern and southern hemispheres.

An elaborate paper by Sir J. W. Lubbock, on the Lunar Theory, will probably be printed in the thirtieth volume of the *Memoirs*. The paper relates chiefly to the correction of the numerical values of the coefficients of the different lunar inequalities; but it contains also an investigation sustaining Prof. Adams' value of the controverted term $\left(\frac{3771}{64} m^4 c^2\right)$ in the expression for the acceleration, and some other theoretical investigations.

The Council regret the loss by death of the following members:—Sir W. Dennison; John Hamilton, Esq.; J. W. Long, Esq.; Charles May, Esq.; Rev. Baden Powell; William Simms, Esq.; and of a late member, Professor Narrien.

The following account of Sir Thomas Brisbane could not be prepared in time for the last Annual Report, the news of the death of its lamented subject being then quite recent.

General Sir THOMAS MAKDOUGALL BRISBANE, Baronet, &c., was of an ancient family, and was born in August 1773; he died January 28th, 1860, in his eighty-seventh year. It is totally impossible to enter upon his career and services. The following abstract is substantially extracted from a publication made by his family:—

Sir Thomas entered the army in 1790, and fought in the first battle of the war, in May 1793, and in the subsequent actions. He went to the West Indies in 1796, and was present at the taking of all the islands under General Sir Ralph Abercromby. He went to the Peninsula in 1812, and commanded a brigade in six general actions, under the Duke of Wellington. He fought in fourteen general actions and twenty-three great affairs, and assisted at eight sieges. He crossed the tropics twelve times, the equinoctial twice, circumnavigated the globe, was in North America, South America, the North of Europe, the Mediterranean, and Australia. In the winter of 1794 he slept for six nights in the snow, with nothing but his cloak and the canopy of heaven over him: he was frozen to the ground in the morning, and during one of these nights 900 soldiers were frozen to death. He was the oldest officer in the army, as he had sixty-nine years of military service.

Sir Thomas Brisbane's devotion to Astronomy began, according to his own account, during his voyage to the West Indies, when the incidents of a gale of wind made him alive to the great use of which navigation and nautical astronomy might be, even to a military man. When in the Peninsula, he regularly found the time by a pocket-sextant, chronometer, and artificial horizon.

During the time he spent in Paris, from 1815 to 1818, with the army of occupation, Sir Thomas Brisbane was instrumental in preventing a rabble of German soldiers from pulling down the buildings of the Academy of Sciences, and in grateful testimony of his services he was thereupon elected a corresponding Member of the Institute.

Sir Thomas Brisbane married in the year 1819 the eldest daughter of Sir Henry Hay Macdougall, Bart., of Makerstoun; through whom he became entitled to the estate of Makerstoun, near Kelso, in addition to his own paternal property of Brisbane.

When the question of sending Sir Thomas to the Government of New South Wales was before the Ministry, Lord Bathurst informed the Duke of Wellington that he wanted a man to govern, not the heavens, but the earth. Sir Thomas appealed to the Duke to say whether science had ever stood in the way of duty. "Certainly not," said the Duke; "I shall say that you were never in one instance absent or late, morning, noon, or night; and that, in addition, you kept the time of the army." Walter Scott wrote of him, that though full of science, he bored no one with it, and was full of general information.

Sir Thomas Brisbane founded three Observatories: one in his public capacity, at Paramatta; two on his own property, at Brisbane and at Makerstoun: at which last place he also founded a magnetic Observatory. In 1828 he received our Gold Medal for his series of observations at Paramatta. The address delivered by Sir John Herschel on its presentation renders it unnecessary to say more at this time.

Brisbane passed his long life without the smallest stain—without even an official mishap. Sound judgment and high principle carried him triumphantly through all the difficulties which lie in the way of the soldier and the administrator: his manners must have not a little contributed to his success. It has been absurdly said that a gentleman, to be the perfection of the character, must not bear the stamp either of his country or of his profession: General Macdougall Brisbane was a refutation of both the points of the assertion; for though in the first five minutes he would have been detected as a Scotchman and a soldier, even though his name and title were unknown, he would in as short a time have been known for a gentleman of the highest breeding; and further acquaintance would have proved that the first appearances were not deceitful.

In estimating the scientific character of Sir Thomas Brisbane, we must distinguish between his claims as an able observer and astronomer in his own person, and as a munificent patron and promoter of science. In the former capacity he takes a high rank, and his acquirements were remarkable. He was a good observer with the sextant, and well versed in every part of nautical astronomy generally, so as to be able to fix

the position of every station at which he might happen to be during his military campaigns. He was also well acquainted with the instruments used in fixed observatories, and was himself a good transit-observer. But it is as a patron of science, by the institution of Observatories, and the encouragement and promotion of Astronomy at a time when its needs were greater and the interest taken in it less than they are at present, that his claims on posterity must be based. The institution of the Brisbane Observatory at Paramatta was a noble work, notwithstanding that, from a variety of causes over which he had no control, the results have been in a great measure nugatory. The chief fault seems to have been in the unsteadiness of the transit-instrument, which has made the results of this Catalogue of Stars in a great degree useless; and it is unnecessary, at this interval of time, to try to determine the degree of blame attributable to individuals. It is, however, greatly to be regretted that the operations of an Observatory so important should not have produced results better calculated to repay its founder.

A similar disappointment did not, however, occur in the magnetical and meteorological Observatory which he established at Makerstoun, in addition to the astronomical Observatory already existing. Sir Thomas was fortunate in his choice of observers, and the results have been of considerable importance. For several years the magnetical observations were most ably conducted by Mr. J. A. Broun, who has since become the Astronomer of the Rajah of Travancore; and several papers on magnetism, in addition to the daily work of the observatory, are evidences of the talents and industry of that gentleman.

We may say, indeed, in summing up the claims of this accomplished gentleman and munificent patron of science to the gratitude and admiration of posterity, that they do not depend in any great degree on the absolute success which has attended his efforts. He saw much more clearly than his contemporaries the need of a well-equipped Observatory in the Southern Hemisphere, and he not only built one at his own expense and provided observers, but he used the influence which his position in the colony of New South Wales gave him to diffuse a taste for astronomical science. In a similar way, when co-operation was needed for the determination of magnetical and meteorological elements, he as freely gave his time and his money for the establishment of an Observatory at Makerstoun, and with the best possible results in the latter case. A rigorous sense of duty seems to have been the guiding principle of his long life of activity and usefulness—the duty of using all his advantages for the good of society and for the extension of science; and he has left behind him a name second to few even in this age so prolific in great and noble characters.

Mr. ISAAC LONG was born in May 1810, and died at Alderly Lodge, Cheshire, May 29, 1860. His father's misfortunes obliged him to maintain himself before his education was completed. While acquiring a handsome independence by long attention to business, he obtained good knowledge of several sciences. He was an industrious observer of the heavens with a 5-inch achromatic telescope equatorially mounted, and was the first to call attention to some remarkable changes in *Jupiter's* belts. He was an expert photographer, and made a fine collection of geological specimens. He was an active member of local societies, and aided with zeal in the dissemination of scientific knowledge. One of the best features of progress in our time is the number of these men who, while succeeding in mercantile life, are actual labourers in literature and science.

CHARLES MAY, F.R.S., was born at Alton in Hampshire, in the year 1800, and at an early age, along with the rest of his father's family, he removed to Ampthill in Bedfordshire. His father belonged to the Society of Friends; his education was of a very limited character, scarcely superior to that of the children of ordinary mechanics of the present day, but the mechanical genius for which he afterwards became so distinguished, began to develop itself at a very early period.

At the usual age he was apprenticed to Mr. Sims, a chemist and druggist at Stockport, whose daughter he afterwards married. At the expiration of his apprenticeship Mr. May returned to Ampthill, where he commenced business on his own account, adding to the ordinary retail business that of a manufacturing chemist on a small scale. He afterwards added a new branch to his business, that of a millwright, the special object being to furnish the requisite machinery for the drug-mills, which, in conjunction with Mr. Stafford Allen, he established in Cowper Street, City Road.

At this period Astronomy became one of his favourite pursuits, and he constructed with his own hands several reflecting telescopes of excellent performance; and although the engrossing nature of his other duties never allowed him to devote much time to practical astronomy, he retained through life a warm attachment to the science.

In the year 1836, Messrs. Ransome of Ipswich, who had for many years carried on the business of agricultural implement-makers, offered him a partnership in their concern, which he accepted, giving up at the same time his other business engagements. Mr. May's department in these works was the *engineering*, and under his vigorous management the concern rapidly grew from a small implement-factory employing about 100 hands to a large engineering establishment known all over the world, and employing 12 or 1300 persons. He remained at Ipswich until the year 1851, when he and Messrs. Ransome

dissolved partnership. He then removed to London and practised as a consulting engineer until his death. Whilst at Ipswich he constructed for the Astronomer Royal the great Transit-Circle and the Altazimuth. These magnificent instruments are justly regarded by all competent judges as models of engineering perfection, and they have inaugurated a new phase in astronomical-instrument-making. Mr. Airy, in one of his Annual Reports to the Board of Visitors, bears willing and grateful testimony to the zeal and ability with which Mr. May carried out his own splendid conceptions.

During his residence at Ipswich Mr. May erected a very elegant and spacious private Observatory, furnished with a transit instrument, clock, and a Merz achromatic telescope of exquisite quality, with an object-glass of $6\frac{1}{4}$ inches aperture. He also constructed the dome at Hartwell House, which covers the telescope formerly belonging to Admiral Smyth, another large dome for Mr. Barclay of Bury Hill, and the equatoreal mounting for the great object-glass of Ross, which graced the memorable Exhibition of 1851, and formed so conspicuous an object in the nave of the palace of glass.

He also distinguished himself by his improvements in the "permanent way" of railways, and was the first to suggest the application of the process termed "chilling" to the pivots of large instruments. He was the inventor of "compressed tree-nails" for fastening railway-chairs to the sleepers.

Such was Mr. May in his professional capacity. In private life his amiable disposition and the combination of kindness and humour which he brought to social intercourse, and his readiness to assist others, made him generally beloved. He became a member of this Society in 1835, and served several times on the Council. He was elected a Fellow of the Royal Society in June 1855, and was also a member of the Institute of Civil Engineers. He died suddenly in August last, and few men have gone to the grave more deeply regretted than Charles May.

The late Professor NARRIEN, of Sandhurst, had retired from the Society, in consequence of ill health, in the year 1858. The Council have not been able to procure any account of his life. He was for many years attached to the Royal Military College, where he was greatly respected and very useful. His name will be preserved by his *Historical Account of the Origin and Progress of Astronomy*, published in 1833. This work, founded on the study of original sources, is an attempt to connect the history of the science with its first elements. It is chiefly devoted to the ancient and middle periods, not extending in detail beyond the time of Newton. There is not, we believe, another work, so nearly popular in its character and appearance, which gives so exact an account of ancient Astronomy. It is a valuable predecessor, both in time and contents, to

the work of Mr. Grant. Mr. Narrien also published some elementary works on mathematics, as part of a course intended for the use of the College in which he taught.

The Rev. BADEN POWELL, F.R.S., was the eldest son of the late Rev. Baden Powell, of Langton in Kent, and was born at Stamford Hill, near London, in 1796. He graduated at Oxford, where he took a first-class degree in mathematics in 1817. In 1820 he entered into holy orders, and in the following year obtained the vicarage of Plumstead in Kent. He was appointed Savilian Professor of Geometry in 1827, and Public Examiner soon afterwards; a post with which he was again honoured in 1831. He thus stood, as it were, the acknowledged representative of mathematical and physical science in the elder English University. We may almost say the only representative; for when he first obtained the professorship, science was at the lowest ebb in Oxford. Mr. Powell exerted himself to bring this state of things before the educated world, by which he incurred some obloquy. But he persevered, and succeeded; the honourable position which Oxford now holds, and the bright prospects of the future, are due in good part to the exposure and remonstrance of the Savilian Professor.

He performed the duties of his chair with urbanity, seeking to encourage his students by explaining and familiarising each point that would allow of it; towards which he had a happy talent of constructing his own models, of the simplest materials, for his practical illustrations. Thus, whenever requested to deliver lectures at public institutions, he came armed with appropriate diagrams and forms that essentially aided the comprehension of those who crowded to hear him. We have thus seen the Undulatory theory of Light treated, and Diffraction made—we may say—palpable. The Precession of the Equinoxes, and the phenomena of Aberration and Nutation, were rendered equally visible; and the hurried progress of Comets when approaching the perihelion, was so attractively shown, that the audience flocked down, after the lecture, to watch the comet vary its speed through its long ellipse towards the sun. His style of delivery was peculiarly quiet, showing his own clear conviction and comprehension of his subject; and his calmness was caused by depth of thought. This sedateness of manner pervaded all his writings and discourses, enabling him even to preach extempore on the most intricate doctrinal points without wandering from his subject.

Meanwhile he had produced various works, as well scientific as theological. Among the first class may be cited his *Treatise on the Differential and Integral Calculus*; and another on the *Geometry of Curves*. In 1834 he published his *History of Natural Philosophy*, and in 1841 the *Undulatory Theory of Light*; besides which he was the author of several papers in the *Philosophical Transactions* on Light, Heat, and

Irradiation. Moreover, his tracts appear in the records of this Society, the Ashmolean collections, and the volumes of the British Association. In the other order of his writings we have to enumerate—besides those for the elucidation of pure religion—the *Connection of Natural and Divine Truth*, 1838; the *Unity of Worlds*, 1855; *Christianity without Judaism*, 1857; on the *Study of the Evidences of Christianity*, 1860, &c.

During the last years of his life Mr. Powell was a controversial theologian. His writings were of a cast which is called liberal by all, but by some in one sense, by some in another. The freedom of his criticism could not but provoke strong attack from his opponents. Of the controversy this Society can take no cognisance, but it must be remarked, as a mere matter of biography, that in his assault upon some modes of theological thought, to which the university once appeared unalterably given, Mr. Powell seems to have been as much of a precursor as in his efforts to stimulate science. The last of his writings appears as one of seven *Essays and Reviews*, most of his colleagues being Oxford men; and the whole of this work, which is in its fourth edition, shows that Oxford names of no mean note are now pledged to admit that freedom of examination which brought so much assault upon the isolated individual who first used it while actually connected with the university. Every meeting of educated men will contain those of the most opposite views as to his conclusions; but all will admire the fearless manner in which, without reference to his own interests, he spoke out the conclusions of his mind.

In the year 1850 Baden Powell was appointed one of the Government Committee of inquiry into the studies enjoined in Oxford; he being well known as an ardent educational reformer, a fact pretty well evinced in his tract on "State Education," considered with reference to "prevalent misconceptions on religious grounds." In 1854 he was selected, at Aberdeen, one of the three judges to award the valuable Theological Burnett Prizes in that city. Nor was the range of his capacity confined to argumentative studies only; for he not only possessed a large fund of general information, but was also a proficient in painting, and was well practised in the choral harmonies of church music, in which science he was a strong amateur.

The Professor's lamented death, on the 11th of last June, was the result of an attack on the lungs which commenced in the previous winter. He had been duly warned of his danger by his medical friends and attendants, several weeks before he expired; but he was resigned to the last, his only uneasiness being a difficulty of breathing, which, after a few days of extreme debility, terminated his existence. He died at his house in Stanhope Street, Hyde Park Gardens, at the age of 63, having scarcely ever been ill before. He was three times

married, and leaves a numerous family. His widow is the daughter of his and our colleague, Admiral Smyth.

Mr. Powell was for years on the Council of this Society, a regular attendant, and a zealous co-operator.

WILLIAM SIMMS was born on Dec. 7th, 1793, at Birmingham, he was brought to London by his parents at a very early age, and when fourteen years old was apprenticed to Mr. Bennet, of Charles Street, Hatton Garden, one of the best "Chamber Masters" of that period, and who was originally a pupil of Ramsden.

Having served his time to the satisfaction of his master, and with credit to himself, he then commenced business as a mathematical instrument-maker at Bowman's Buildings, Aldersgate Street, in the City of London.

He was early connected with the Society of Arts, and became acquainted with several of its most eminent members, in consequence of the exhibition of a peculiar protractor of his own contrivance. This led to his introduction to the late Francis Baily, Esq., and Bryan Donkin, and through the latter to Col. Colby, then Superintendent of the Ordnance Survey.

Col. Colby was at that time in want of some large theodolites, and trusting to the representations of the friends of Mr. Simms as to his capabilities, was induced to give him an order. These instruments were completed so much to the satisfaction of the Colonel that other orders soon followed, and a large business speedily became the result.

Mr. Simms joined Troughton in 1826, and after a partnership of five years (Mr. Troughton retiring) carried on the business until his death.

He became a Fellow of the Royal Astronomical Society in 1831, and of the Royal Society in 1852.

He died at his residence at Carshalton on the 21st of June, 1860, and was buried in his family grave at Norwood Cemetery. The works of Mr. Simms are too numerous to be described here, most of them are well known, and accounts of some are to be found in the Memoirs of the Society.

By his connexion with Troughton Mr. Simms could not but acquire a well-known name; but it must be remembered that he was possessed of great skill and ability, and was not unworthy to be associated with his celebrated partner. The Cambridge Mural Circle, and the whole of the instrument-maker's part of the Greenwich Altazimuth, Transit-Circle, Reflex Zenith Tube, and Great Equatoreal, with many other instruments of repute, were the work of Mr. Simms. The admirable 8-inch object-glass of the Greenwich Transit-Circle also was ground by him. His improvements in the graduation of instruments were in some cases so much the work of time as to be hardly capable of being signalised as improvements at any one moment. By his self-acting dividing machine he

reduced the work of weeks to the work of hours, as well as improved the accuracy of the process, and contributed important aid to the distribution of well-divided instruments for the ordinary purposes of navigation and surveying. The Astronomer Royal, when engaged in the construction of the Greenwich Transit-Circle, after anxiously examining the various methods of graduating the Zenith-Distance-Circle, satisfied himself that it would be done most accurately by the use of Mr. Simms' dividing-machine; and the excellence of the result has proved the correctness of the decision.

Mr. Simms's character was remarkably one of fairness and candour. Persons who transacted much business with him, though they began with him in his character of tradesman, usually learnt to recognise him as a friend.

Mr. Simms was an active member of our Council at several different periods. His services were given in his own quiet and unpretending manner. His voice was little heard, but his colleagues knew that his sound judgment and hearty co-operation could be relied on.

The observations at the Royal Observatory, Greenwich, maintain that steadiness of character which has given to its publications so great a value. In the last summer the great Equatoreal was made efficient, but the absence of the Astronomer Royal for observation of the eclipse and other interruptions have prevented it from being brought into regular use. It has, however, been employed to a considerable extent in the preparation of delineations of *Jupiter* and *Mars*. The former of these planets has exhibited, in the last year, some appearances never before recorded; and it has appeared very desirable to register, as soon as possible, anything which seems to indicate a change in the constitution of that great body.

The time-communications of the Royal Observatory (of which the population of the British Isles is every day availing itself to an extent of which it is little aware) are now made by galvanic signals conveyed by open-air wires.

The Astronomer Royal retains the intention, as soon as the state of reductions shall permit, of preparing a 7-years' Catalogue of Stars from the observations made at the Royal Observatory from 1854 to 1860.

The printing of the *Greenwich Observations* for 1859 is finished in all important points. Some additions are contemplated, which will prevent its distribution for a short time.

Mr. Main has been succeeded, as First Assistant, by Mr. Edward James Stone, Fellow of Queen's College, Cambridge.

From the Royal Observatory, Edinburgh, we have a printed Report addressed to the Board of Visitors there, on the 24th of April, 1860; and have further accounts to the end of January 1861.

The printing of the past observations with transit instrument and mural circle has been in continuance, and has reached the end of 1858. The instruments themselves have had some subsidiary applications made to them, to promote the facility and precision of handling and using them for ordinary observations; and some of an extra character have been applied to the shutter openings of the transit instrument, as well as to the telescope itself, to fit it for a special series of measures, adapted to inquire into the supposed "Solar Refraction" of Prof. W. Thomson. This series commenced on the 1st of May, and for two or three days went on somewhat hopefully; but immediately thereafter began a cloudy season, which continued without any interruption during nearly the entire summer, and especially during the period of the larger stars in *Taurus* and *Leo* being near the Sun's place. Attention had been called in the printed report to the unequalled opportunity which the then approaching solar eclipse would give, to those who should be within the range of its totality, for observing stars situated favourably and effectively to develop the solar-refraction effect to a definite and tangible amount, should it really exist to the degree and in the manner anticipated. It is believed, however, that amongst the numerous and more certain phenomena which occupied the attention of the many able astronomers who witnessed the eclipse in Spain, the solar-refraction question did not form one of them; and hence it is left to future times to make, during the dark interval of another total eclipse, an observation pregnant (it may be) with important result on the physics of the Sun and the Solar System, simple and straightforward in itself, but which has never been made yet from the commencement of the world; viz., the measure of the distance of two stars, not more than two or three degrees apart, when the Sun is apparently between them. Although the Edinburgh Observer was unable to visit Spain, he had communicated with some who were more fortunate, and has since been assured that there is every reason to believe that a 6-inch object-glass would have been able to show stars of the 5th or 6th magnitude, at not further than half to three-fourths of a degree from the border of the Moon's disk when completely eclipsing the Sun.

The occultations of the *Pleiades* in September were duly observed at Edinburgh, in concert with the Americans; and by means of an electrical apparatus, which so intensified the seconds'-beats of the transit clock, as to enable them to be heard equally by the transit observer, and by the watcher of the occultations, in opposite parts of the building.

The electrical time-ball, daily worked by the Observatory, has given rise amongst the citizens of Edinburgh to a desire to have its visible manifestations supplemented by an audible signal, in the shape of a cannon in the Edinburgh Castle, to be fired by electrical signal from the Observatory. This desire

has not only manifested itself at the meetings of public commercial companies, but also in the collection of so large a subscription to pay for the expenses of the connecting wire, and the gunpowder, that Her Majesty's Government have been pleased to entertain the proposal to some extent, and experiments were lately made by the military in the Castle, as to the best size of gun, charge of powder, and general position.

The Edinburgh Observatory still carries on the reduction of meteorological observations from 55 stations in Scotland, for the Registrar-General's Department; and in the course of a special inquiry undertaken with regard to the circumstances and characteristics of a remarkable and destructive storm on October 3d, 1860, it has had the honour of receiving special communications of hourly or other frequent observations from the several establishments of Greenwich, Oxford, Glasgow, and Armagh; from the Imperial Observatory of Paris, with returns from several French stations; and similarly, from the Royal Observatory of Brussels, from the same of Christiana, Königszberg, and Utrecht, from the Imperial Physical Observatory of St. Petersburg, and from Altona, Copenhagen, and Iceland.

The ultimate reputation of an Astronomer in a public Observatory rests in part upon his successor, upon whom depends the manner in which his growing crops are brought to maturity. The appointment of the Rev. R. Main, in June last, to the Radcliffe Observatory at Oxford will secure to our lamented late colleague, Mr. Johnson, the full credit due to his acknowledged skill and industry. This appointment has given high satisfaction to the astronomical world; the subject of it being their own President, the Council will say no more. During the interval between the death of Mr. Johnson, in March 1859, and this appointment, the Observatory was in charge of Mr. Quirling, the First Assistant, and meridian observations of stars were made with the transit instrument and the meridian circle to as great an extent as his own unassisted strength permitted. The meteorological observations were carried on without interruption during this period by Mr. Green. The printing of the Radcliffe Catalogue of Stars was also completed. This important work is noticed in another part of the present Report.

On Mr. Main's assuming the direction of the Observatory his first care was to provide for the publication of the Radcliffe Catalogue, and the examination and revision which were necessary occupied him for some time. The next point of importance was to put the Heliometer into a state fit for observing. Its general condition was very satisfactory, but the telescope was found to work so stiffly in its collars that it would have been impracticable to use it with effect for measuring angular distances, and, there being no provision for illumination of the field, it could not be used as an ordinary

equatoreal instrument. This defect of stiffness having been remedied, the telescope-tube was also perforated near the eyend, and a ring-reflector was inserted for throwing light down the telescope by means of a small lamp, and by this means good illumination is obtained. The only circumstance to be regretted is that, by the taking out of the object-glass, some small disturbance has taken place in the relative position of the halves, so that at the zero, when the images ought to cover each other they are again separated by a small interval. This defect will be removed on the first opportunity, and the instrument will be then in a thoroughly satisfactory state.

The meridian instruments are employed chiefly for the completion of the observation of Mr. Johnson's "*Catalogue of Remarkable Objects*," and Mr. Main proposes to commence shortly the compilation of another *Star Catalogue*, which shall include the places of all the stars which have been observed from the year 1854 to 1861, both inclusive. He proposes also to employ the heliometer for the observations of the larger planets, and for observation of a catalogue of Double Stars.

While thus passing in retrospect the now concluded labours of the late Mr. Johnson, the Council take this opportunity of making some remarks which they think worthy the notice of those who are members of the governing bodies of our public Astronomical Institutions. They are aware that questions of policy in regard to expenditure arise from time to time, and are decided on their apparent merits at the time, and that trustees may often wisely hesitate to follow every recommendation to supply new and expensive instruments. In a manufactory, a Principal, while certainly not adopting all the promising schemes which patentees are too ready to put before him, will take care as early as his means permit, to introduce any new and improved machinery whereby better and increased production may be profitably secured. In an Observatory where profit is not the motive, but economy and improvement should be, it is equally bad policy to retain old instruments too long, when the introduction of new ones would enable the Astronomer and his staff to do in one year the work of three with the old. It is to be remembered also, that when by defect of instrumental arrangement or deficiency of computing power, a limited work is thrown over a needlessly long term of years, the risk of the Astronomer's labours being left incomplete by his death, and perhaps never made available at all, is also greatly increased. Mr. Johnson's life was fortunately continued sufficiently for his work to have escaped all but the final risk of injudicious publication, and this has been avoided by the care and interest of our President. Another instance has lately occurred in which our science has had better fortune than was apparently insured by the arrangements of foresight. The recently published *Armagh Catalogue* is the

summary of so protracted a series of observations that the happy result can only be regarded with the feeling of those who have escaped shipwreck. With good organisation and a good transit circle, such as Groombridge had, the work of revising the Catalogue of Groombridge might certainly (judging by the Redhill Catalogue of Mr. Carrington) have been performed within five years; and if this view be correct, it is clear that the possession of such an instrument would have left years of Mr. Johnson's life free for the attainment of still further results. It is part of the self-constituted duty of a deliberative body, such as the Council of this Society, to point out with respect, but still with candour and completeness, any course which sound policy may recommend for the prosecution of astronomy. The Astronomer Royal once calculated the cost to the country of one complete observation of the Moon in both elements, including rental of premises or the equivalent, wear and tear of instruments on a series of years, share of salaries, printing and incidental expenses, and we believe he made it about 10*l*. We do not often dwell on the cost of our productions, but it is desirable that the costliness in mere money should not be lost sight of, whether the country supply the funds or there be an endowment of private origin concerned. We should much like to see a competent examination, with the cost per thousand of concluded positions of stars (with due regard to the degree of accuracy attained) for different establishments, and have little doubt that at the head of the list of economical production would stand Bessel's Zone-observations. The admirable work now in hand by Dr. Argelander, though designedly of another order of execution, calls for notice in this respect, but would lead our intended remarks beyond the object in view.

The ordinary work of the Cambridge Observatory is described in the usual Report of the Observatory Syndicate. Shortly after the date of the Report (May, 1860) Mr. Challis succeeded in engaging a second computer, who, as well as the first, is paid from the proceeds of the Sheepshanks Fund. With the aid of his two assistants and the two computers, he made great progress in the latter half of last year in the reduction of the meridian observations of past years, which was advanced completely to the end of 1857. The meridian observations of the three last years, which were comparatively few, are now occupying attention. The observations of late have been of a miscellaneous character, and the number of the regular meridional and equatoreal observations has been much diminished. Since May of last year, meridian observations have been resumed solely for the purpose of determining the places of comparison stars. Some good micrometer measures of the solar eclipse of July 18 were obtained, and the scrutiny of the Sun's disk for detecting intramercu-

rial planets has been continued, but without success. Last summer, as during several previous years, the corrections required for the effect of the forms of the transit pivots on the times of meridian passage were ascertained. The conclusion arrived at is, that unless this source of error be continually guarded against, determinations of differences of longitude cannot be depended upon.

Professor Challis completed, in the summer, a second series of measures with collimators moveable about the Mural Circle, for the purpose of ascertaining the effect of flexure on the circle readings; and the result obtained was, that six microscopes almost entirely eliminate errors of reading due to flexure of the material, care being taken to have a uniform temperature in all parts of the circle room. The discordance of zenith points exhibited in direct and reflected observations with the large Circle is to an amount which flexure of the material will not account for.

The Sheepshanks Fund has hitherto only been devoted to paying computers, and that to a moderate amount, so that the proceeds are accumulating. What Professor Challis has recommended is, to employ the reserve fund, when of sufficient amount, in purchasing a new Transit-Circle, which this Observatory stands much in need of; neither the transit nor the mural circle being now as good and efficient as the present state of astronomical science requires.

Professor Challis has laid before the Council of the Senate a formal request to be relieved from the duties of the Observatory, retaining the Professorship. A syndicate has been appointed to consider the matter, and report in the course of this term. His reason for making the request is, that he has been actively engaged as a practical astronomer for twenty-five years, and thinks he will do well to retire from this kind of duty before he is unable to discharge it, and while he is capable of astronomical and scientific work demanding less bodily exertion, and in great measure arising out of the practical work which he has done at this Observatory. Under these circumstances, it is to be hoped that Professor Challis will remain in fact, though not in name, closely connected with the Observatory which he has so long and so ably conducted.

Vol. xix. of the *Cambridge Observations*, containing the meridian observations of 1852, 1853, and 1854, is not yet published, a few sheets of the Introduction remaining to be printed. The delay has been caused by its being necessary to insert a great deal of fresh matter into the Introduction, in order to describe fully new apparatus and new modes of observing adopted in the course of those years.

Professor Grant obtained definitive control of the Glasgow Observatory in the month of May last year. The principal

instrument of the establishment is a meridian circle of 3½ feet diameter, by Ertel of Munich, with which a course of observations has been commenced. A portion of the results, consisting of observations of the Minor Planets, has been recently forwarded to Professor Peters for insertion in the *Astronomische Nachrichten*. Meteorological observations continue to be made nearly on the plan hitherto pursued. Steps have been taken for establishing an electric communication between the Observatory and the central parts of the city, with the view of transmitting correct Greenwich time from the Observatory, by the method which Mr. Hartnup has practised so successfully at Liverpool.

At the Liverpool Observatory Mr. Hartnup has been engaged in alterations, now nearly completed, which have been progressing during the past nine months. A new chronometer-room, library and computing-room, have been added to the establishment. In the former, every possible care has been taken to render it as perfect as practicable for testing and ascertaining the rates of chronometers in different temperatures. This room, which is eighteen feet by twenty-eight, has a large double skylight, and the walls, which are very thick, have a cavity between them. The room can be warmed by hot-water pipes, which are carried under the floor, but this will not often be required, as there are in the room two warm-air chambers which will hold upwards of one hundred chronometers each. The tops of these warm-air chambers are made of plate-glass, so that the chronometers standing in their boxes, with the lids open, may be compared as frequently as desirable, and their rates in different temperatures ascertained without moving them from one place to another. The heating is all by gas, the pressure of which is regulated by a governor. The arrangements are so perfect that Mr. Hartnup hopes soon to see the rates of the chronometers, deposited at the Observatory by makers for the purpose of showing the perfection of their performance, published at regular intervals. The rates in different temperatures supplied to mariners will also be much more perfect than it was possible to obtain with the old arrangements.

The performance of the large clock at the Victoria Tower, which is controlled by Mr. Jones' method, has been very satisfactory. The striking of this large clock is quite simultaneous with that of the Liverpool Town Hall, which is also controlled in the same way, and at 1 P.M. they may be seen to be coincident with the dropping of the time-balls. The dropping of the Victoria Tower time-ball, by a mechanical arrangement with the distant clock, which is controlled by the Observatory normal clock, has been found to answer perfectly, no error having arisen from want of battery power or from any irregularity in the passage of the galvanic current.

The general routine duties of the Observatory have been carried on much in the same way as in former years, but the extensive alterations above named have prevented Mr. Hartnup from doing much with the Equatoreal.

The great activity of the Sun in producing spots during the year 1860 has restricted the attention of Mr. Carrington and his assistant almost entirely to their observation and treatment. The past year has been one of maximum action; and it may give some notion of the constant pressure of the subject on the observer, when it is stated that, of the stock of about 5000 accurately reduced positions, accumulated by Mr. Carrington since the beginning of the year 1854; 1893, or nearly two-fifths, are the produce of the past year. Much of this is attributable to the interest and assiduity of Mr. von Bose, by whom the greater part of the actual labour was performed. Mr. Carrington greatly regrets that at the close of the year Mr. von Bose was obliged to leave him, in order to resume the profession of chemistry, for which he retained a preference; and he cannot expect easily to meet with another assistant equally valuable to him.

It may appear to some that in thus largely observing in this field, an unreasoning instinct for the accumulation of any sort of observations is exhibited; but Mr. Carrington is deliberately following out a plan laid down at the commencement, of subjecting this phenomenon to severe record throughout one complete period, and it will be the fault of circumstances beyond his control, if this record should be interrupted before the next minimum is past. A sound basis of thorough observation has never before been laid in this department of astronomy, from which replies might be obtained to many hypothetical questions as well as to others suggested by the indications of the observations themselves. Reductions to place on the Sun have kept pace with the record, the whole of the observations of the past year being already worked out. Further discussion of these places will be pursued as his leisure permits.

Mr. Carrington called the attention of the Society in the month of May last to a first draft of the periodic variations of frequency for the past 120 years, concluded from the researches of Prof. Wolf into old documents mostly in MSS., and he would now again call attention to the last communication of his indefatigable co-labourer, wherein he has given his concluded relative numbers for this period of years, expressed in the same unit. The curve formed by laying down these numbers offers as interesting a problem for solution as any that has been laid before astronomical inquirers.

Mr. Lassell informs the Council that the two lithographs sent to the Society are almost the only fruits of the 4-foot Equa-

toreal. The anomalous weather, remarked by everybody, has made the instrument hitherto comparatively useless. He has been occupied in grinding and polishing a second, or reserve speculum, B, which is now in the tube, and is, he believes, fully equal in form of curvature to A, perhaps superior to it; for a little falling off of perfection towards the edge in A he does not detect in B.

But he has waited hitherto in vain for such a quality of sky as would enable him to determine the real amount of superiority of efficiency of this telescope over the 2-foot Equatorial, whether it approaches its theoretical ratio of two to one.

At the Hartwell Observatory, since the 1st of January, 1859, till his sudden appointment, last October, to the Madras Observatory, on the recommendation of the Astronomer Royal, Mr. Pogson has been assiduously carrying on his researches on variable stars, and taking advantage of every opportunity for completing the sidereal charts connecting those of Berlin and Regent's Park. The Variable-Star Atlas is to be completed at Madras, with the express permission of Government.

Mr. De La Rue states that in his own Observatory at Cranford he has, during the past year, pursued photographic observations as continuously as the very unfavourable weather would permit.

Considerable improvements have been made in the driving machinery of his telescope, which leave but little to desire; and, as a necessary consequence, very fine lunar photographs have been procured. During the year whole constellations have been photographed by him: as two extremes, may be cited the *Pleiades* on the one hand, and *Orion* on the other. Since his return from Spain he has engaged Mr. Reynolds, one of his assistants during the eclipse, with the object of prosecuting celestial photography without interruption, should the weather, which has hitherto been very unpropitious, permit.

Among the works for the present and future years may be mentioned the following: the photography of the Sun's spots on a scale sufficiently large to admit of the study of the changes which they undergo from time to time; in view of which it is proposed to make these photographs on the scale of five feet to seven feet for the Sun's diameter; the exact determination of the libration, and of the diameters, polar and equatorial, of our satellite.

The work of the Kew photoheliograph has been considerably interfered with by the preparations for the trip to Spain, which necessitated various additions to the instrument; and since the return of the expedition Mr. Beckley's other avocations, together with the badness of the season, have prevented its employment on as many occasions as could be desired.

In consequence of the press of meteorological work now performed at Kew, the committee find it difficult to make adequate arrangements for the systematic continuance of the work of the photoheliograph, and it has been proposed to Mr. De La Rue to take charge of the working of the instrument at his own Observatory.

It is almost unnecessary to recall the attention of the Society to the phenomena and observations of the important total Eclipse of the Sun of 1860, July 18. Never before has the totality of an eclipse been observed by so many persons, nor probably ever through such an extent of country. In the year 1842 we believe that only two persons (the late Francis Baily and the present Astronomer Royal) made journeys out of England expressly for the purpose of seeing the total eclipse. In 1860 about forty observers went from England to Spain for that observation. From Scandinavia to Italy, astronomers, official and private, converged to the northern provinces of Spain; the French Government equipped an admirable and well-arranged expedition to Spain, at the same time providing for observations in Algeria; and the services of the British Government, in the appropriation to the use of astronomers, of the magnificent steam-ship the *Himalaya*, and in the making every conceivable provision for their wants and their comforts, will not be soon forgotten. The United States of America did not omit to establish temporary observatories at some of the most important points on the new continent; and finally (though first in absolute time) the totality was perfectly observed and carefully depicted by a British officer in the neighbourhood of Vancouver's Island, where the elevation of the Sun above the horizon was less than three degrees. Most of the foreign observers, and some of the English, have published their accounts, in different degrees of detail. But it has been found impossible hitherto to sufficiently examine, with a view to digest, the vast mass of accounts, principally from the *Himalaya Expedition*, which have come into the hands of the Astronomer Royal.

The part which photography has played in some of these observations will be presently referred to.

At places beyond the band of total obscurity the eclipse has been carefully observed. At our National Observatory, an extensive series of transit-observations and micrometer-observations was arranged, with the view of furnishing materials for ascertaining the errors, at that time, of all the tabular elements involved in the computation of the eclipse.

During the past year photography has proved itself of great value in exact astronomy. The solar eclipse of July 1860 afforded an excellent opportunity for testing the value of this method of recording phenomena, the duration of which is

so short as to defy all attempts of the most able observers to register them with precision by optical means, however much a preconceived division of labour may reduce the amount of work to be done by each individual observer. Of the various problems remaining to be solved by observations of the total eclipse of the Sun in July last, the most interesting, perhaps, was the determination of the precise nature of the so-called red prominences, which were first seen in the solar eclipse of the year 1842. Fortunately, two photographic records, at two stations nearly 240 English miles apart and with instruments of a different character, have so confirmed each other as to place beyond all doubt the real existence of these phenomena. Mr. Warren De La Rue, operating with the Kew photoheliograph at Rivabellosa, near Miranda del Ebro (about lat. $42^{\circ} 42' 5''$ N., long. $11^{\text{m}} 42'$ W. 17 miles, towards the *north*, from the central line), and M. Aguilar, associated with Father Secchi, employing the Cauchoix telescope belonging to the Observatory of the Collegio Romano, at Desierto de las Palmas (about lat. $40^{\circ} 4' 4''$ N., long. $0^{\text{m}} 11' 6''$ W. $4\frac{1}{2}$ miles, towards the *south*, from the central line), have obtained photographic representations of the different phases of the eclipse, including the totality.

These records of the appearances during the totality are quite concordant *inter se*, and one with the other, and show, incontestably, that the Moon gradually covered and uncovered luminous prominences which retained a fixed position with respect to the Sun. It thus appears impossible to doubt but that they are real appendages of the Sun; without, however, denying that their appearance may be altered by refraction at the Moon's surface. The popular results of these photographic observations have already been made public through the newspapers and scientific journals, but the subsequent discussion of the facts recorded has served to render still more manifest the great value of these photographic results.

Mr. De La Rue's photographs during the totality were two in number, but these two afford four epochs for the determination of exact numerical data. M. Aguilar's photographs of the totality, which measure 9-10ths inch in diameter, were four in number, but are wanting in that precision of details apparent in those of the former gentleman, which measure four inches in diameter. Mr. De La Rue procured by his well-arranged plans 31 photographs of the other phases of the eclipse, and has given to the Society, at two of its meetings, a *ridá voce* statement of the measurements of the photographs, and of the results they establish. These results may be thus briefly stated:—The photographs having been advantageously enlarged, for purposes of observation, to 9 inches and 13 inches in diameter, measurements of the lunar and solar diameters give data, in regard to the ratios which they bear to each other, almost absolutely in accordance with theory; moreover,

with respect to the Sun, his equatoreal diameter is found to be measurably greater than his polar diameter. Measurements of the chord and of the versed sines of the cusps of the Sun and Moon give accordant results in regard to the angles of position of the line of centres of the Sun and Moon, and of their respective diameters; and, consequently, the distance of the Sun and Moon centres at the epoch of each photograph. With these data, the direction of motion of the Moon's centre, and the nearest approach of the lunar and solar centres, are determinable with great accuracy. Having found the relative positions of the centres of the Sun and Moon, Mr. De La Rue has etched upon an enlarged photograph on glass of the Sun, 9 inches in diameter, the luminous prominences seen on the first and second of the totality photographs, and has thus referred them to the Sun's centre, with great precision. Copies of the first photograph of the totality, superposed on the second, coincide absolutely in respect of those prominences visible in common at both epochs, and on both the first and second photographs can be traced the extent and direction of the Moon's motion.

The movement of the Moon apparent on each individual photograph, and the extent of movement evidenced by a comparison of the two photographs, are in strict unison with the demands of theory. One unexpected result of the use of photography in this case was, that it rendered evident the presence of certain prominences which, on account of their being not more luminous than the surrounding corona, did not impress the eye, but which, from the fact of their being of different actinic power, were nevertheless detected by the sensitive plate. Another remarkable and unlooked-for fact in connexion with these observations was, the great brilliancy, optically and actinically, of the luminous prominences and corona. The Kew photoheliograph, in which the focal image is magnified eight times, and its intensity consequently diminished fully 64 times, gave an impression of the luminous prominences in 20 seconds, and of the corona in one minute; whereas it did not give the slightest trace of the image of the Moon at full in one minute; and in the Cauchoix telescope the unmagnified focal image of the corona was well imprinted in 20 seconds.

The Council have to notice an error in the Annual Report for 1859, February 11. In the account of discoveries of small planets, *Calypso* ☿ is attributed to M. Goldschmidt. As noticed, p. 166 of vol. xviii., it was, in fact, discovered by Dr. Luther, at Bilk.

During the twelve months which have elapsed since our last anniversary, five new bodies have been added to the group of Minor Planets revolving between *Mars* and *Jupiter*. The first (*Concordia*) was discovered on the 24th of March at Bilk

by M. Luther. The second (unnamed) was discovered on the 12th of September, at Paris, by M. Chacornac. The third (*Danaë*) was discovered on the 9th of September, at Paris, by M. Goldschmidt. The fourth (*Titania*) was discovered on the 14th of September at Washington, by Mr. Ferguson. The fifth (*Erato*) was discovered on the 14th of September, at Berlin, by Dr. Förster and M. Lesser, who determined its position under the impression of its being identical with the planet discovered on the 10th of the same month by M. Chacornac. Its existence as a distinct planet was established in the course of the following month. The total number of bodies constituting the group of Minor Planets now amounts to sixty-two.*

The list of Comets has been enriched by the discovery of four new bodies of this class in the course of the past year. The first was discovered on the 26th of February, at Olinda, in Brazil, by M. Liais, who saw it only on three subsequent nights, the presence of moonlight having prevented further observations of it. From its extreme southern position it was invisible in Europe. The observed places have been satisfactorily represented by a parabolic orbit. This comet exhibited the interesting phenomenon of two distinct heads.

The second comet was discovered on the 17th of April, at Hamburgh, by Mr. George Rümker. It was a faint telescopic object, and continued visible only during a short time. The elements of the orbit have been found to be sensibly parabolic.

The third comet was first seen on the 20th of June, at Utrecht, by M. Gronemann, and on the same day by Prof. Caswell, on the deck of the steamship *Arabia*, while on his voyage to England. When it attained its greatest brilliancy it was visible to the naked eye, and formed a conspicuous object in southern latitudes, where it continued to be observed till towards the end of August. M. Liais has found that the observations would be best represented by an elliptic orbit, with a period of about 1089 years.

The fourth comet was discovered on the 23d of October, at Marseilles, by M. Tempel. The observations of it consist solely of two places determined by the discoverer, and one by M. Villarceau at Paris, moonlight having soon rendered it invisible. From these observations a parabolic orbit has been calculated by M. Valz, who remarks that the elements bear some resemblance to those of a comet discovered by Pons in 1822.

The Council are happy in being able to announce, in their

* Since the date of the Meeting a sixty-third Minor Planet has been discovered by M. de Gasparis: see the conclusion of the present Number. — Ed.

Annual Report, the publication of the Radcliffe Catalogue of Circumpolar Stars. The delay in the appearance of this great work, the result of Mr. Johnson's star-observing for fourteen years, was caused solely by the temporary interregnum at the Observatory after his death, as the printing of it (with the exception of the Introduction) was completed in the summer of 1859. Copies were, however, most liberally distributed by the authority of the Trustees on its publication in December last, to the various institutions and individuals in every part of the world, who have an interest in astronomy, and there is no doubt that it will not disappoint the expectations of astronomers. It gives the accurate places of 6317 stars; most of them circumpolar in this latitude, the greater part of which are determined by not fewer than three observations in each element, while those stars included in Groombridge's catalogue of circumpolars, have been observed at least five times. The bringing up of Groombridge's places to the epoch of the Radcliffe Catalogue, and the comparison of the results, though it added considerably to the labour of the computation, forms a most useful part of the work, because, by this means, the proper motions of all these stars, amounting to 4243, have been virtually determined, and a basis is laid on a large scale for speculations in such branches of sidereal astronomy as depend on the proper motions of the stars. Amongst the subjects for congratulation in the active progress of various branches of Astronomy during the past year, the publication of this valuable catalogue must be reckoned among the greatest.

Among the astronomical works which have appeared during the last year, probably the greatest and most important is the *Theory of the Moon's Motion*, by M. Delaunay. Of this great work, which has been eagerly expected by astronomers, the first volume was presented to the Academy of Sciences by M. Delaunay at the meeting of December 24 last, and it forms the twenty-eighth volume of the Memoirs of the Academy. By the various discussions which have recently taken place concerning the lunar theory, and particularly by the controversies of its most distinguished investigators, the members of this Society have been made acquainted both with the magnitude and the enormous labour of the work in question, and also with the peculiarities of the method employed by its author, as far as he himself had given explanations in his various papers which appeared from time to time in the *Comptes Rendus* of the Academy. But the published work gives information on both these points which could not have been anticipated. With regard, for instance, to the labour expended upon it, it is sufficient to say that the development of the disturbing function was effected by means of 57 operations, and that the number of periodical terms in it is 461, occupying 138 pages of the printed work. In his preface M. Delaunay gives a very clear

account of the various processes which have been employed in effecting the developments in the lunar theory since the time of La Place, and of his means for pursuing his coefficients to the end of the work in their literal form, this being one of the chief points of difference of opinion between himself and M. Hansen. The peculiarities of his process are best given in his own words:—"In conformity with the excellent Memoir of Poisson of 1833," he says, "I have taken for my point of departure the differential equations furnished by the theory of the variation of arbitrary constants, and I have adopted a system of elliptic elements such that these equations may have the most simple form of which they are susceptible. The perturbing function, of which the partial derivatives, relative to the elliptic elements, furnish precisely the value of the derivatives of these same elements with respect to the time, may be easily developed in a series of periodical terms. If we did not take care, the introduction of this periodical series into the differential equations would be attended by a serious inconvenience: the time would result from terms involving sines and cosines, which would be a considerable check upon the employment of these differential equations for the determination of the lunar inequalities. I get rid of this inconvenience by a very simple method, which differs essentially from those employed before me for the attainment of the same end, and which has the great advantage of leaving to the differential equations the form which they had at first. As to the perturbing function, it is found by this means modified in such a way that the time no longer enters into it implicitly, excepting as it is introduced by the values of the co-ordinates of the disturbing bodies, and, in addition, a certain non-periodical term independent of the perturbing actions of these bodies. This being done, I suppress from the perturbing function the totality of the periodical terms which it contains, with the exception of one only, which I choose amongst those which have most influence in producing inequalities. In introducing this function, thus simplified, into the different equations, I find that they are completely integrable. I then profit by this integration to deduce from it formulæ, the office of which is to replace the six variables which I had by six others of the same kind. When, by the use of these formulæ of transfer-matter, the new variables are substituted for the old ones in the perturbing function and in the expressions of the co-ordinates of the moon, it results, first, that one of the important terms of the perturbing function disappears (the periodical terms which at first had been alone retained); secondly, that different inequalities corresponding to this term are introduced into the values of the three co-ordinates of the Moon; and further, that the values of the six new variables in functions of the term are determined by differential equations of precisely the same form as those which determined the values of the six variables for

which they have been substituted. Thenceforward, the integration of the differential equation being brought to the same point as in the preceding case, excepting the disappearance of a periodical term in the perturbing function, a new operation analogous to that which has just been effected causes in the same way another term of this function to disappear; a third term may in the same way be taken away from it by means of a third analogous operation, and so on. In this manner, after there have been effected a sufficient number of operations of this kind, the perturbing function is found to be rid of its most important terms, and the problem is thus rendered simple enough to be treated in the same manner as if it were a question of the perturbations of a planet or of the Sun."

The author, after giving a summary of the published volume, states that the second volume will contain, 1st, the different formulæ the office of which is to take account of the terms which remain in the perturbing function after the fifteen preceding operations have been effected; 2dly, the expressions of the three co-ordinates of the moon, with *all* their qualities to the seventh order inclusively for the longitude and latitude, and to the fifth order for the reciprocal of the radius-vector; 3dly, various chapters intended to complete these expressions of the co-ordinates of the Moon, by taking account of everything which had provisionally been put on one side for purpose of having to consider only the capital portion of the problem.

Such is a brief account of perhaps one of the most laborious analytical works ever accomplished by a single individual. For fourteen years the author has been working without the assistance of a single computer, and uncheered by anything but his own clear views of his theory, and his consequent conviction that the result, when accomplished, would be worthy of the pains bestowed upon it. We may congratulate not only this Society, but the civilised world, on having at length before it this imperishable monument of combined human industry and talent; and at the same time offer also our congratulations to M. Delaunay that he has at length seen the end of his severe labour, and is now reaping the fruits of it in the intrinsic value of the work, and in the respectful admiration of contemporary astronomers.

During the past year has been published a new Catalogue of the Library of the Pulkowa Observatory, by M. Otto Struve. Though the titles are briefly given, they fully serve to identify; and this publication is very valuable. Great pains must have been taken to form this collection. The difficulty of forming a tolerably complete collection of known works—that is, already described by bibliographers—can only be matched by the facility with which a collection may be made of works which bibliographers have *not* enrolled. Lalande, whose bibliography

has not been surpassed in extent, has in his list works of the 15th, 16th, and 17th centuries, to the number of 2193. Of these the Pulkowa library possesses 973 works, or one out of three. Nevertheless, this same library could add one out of three to Lalande's list; for it possesses 905 works of the three centuries in question, of which Lalande knew nothing. It says something for the biographical utility of our Society that there are five *foreign* astronomers of whom no biographical accounts have found their way to Pulkowa except those in our *Monthly Notices*.

It will be in the recollection of the Fellows of the Society that, after a notice by the Astronomer Royal of the fitness, in different parts of the earth, of the summers of 1860 and 1862 for observations of *Mars* with a view to determine his parallax, an ephemeris of *Mars* and a catalogue of comparison-stars, illustrated by an engraved chart, were circulated by the Society, for facilitating the required observations. The proposal, however, failed totally. The northern observers, both in Europe and in America, were all so much interested in the observation of the total Eclipse of the Sun as to be unable to undertake the observations of *Mars*, and, even if astronomical engagements had permitted it, the bad weather and the southern declination of *Mars* would have greatly diminished the opportunities of observation. At the Observatory of Madras, the Observer (Major Tennant) judged the mounting of his Equatoreal (in the German form) to be too unstable to give trustworthy results; and at the Cape of Good Hope, the Observer, we believe, was distracted with other occupations. The Society will doubtless be anxious that every effort should be made to apply this method effectually at the ensuing opposition of *Mars* in 1862.

The Astronomer Royal, in his remarks upon the means at our disposal during the next few years for determining the amount of solar parallax, adverted to the importance of new tables of the planet *Venus*. Our illustrious associate, M. Le Verrier, has recently supplied this desideratum in so complete a manner as to leave little or nothing to be desired. His theory of the planet, which is almost wholly founded on the observations taken at the Royal Observatory, Greenwich, since the time of Bradley, with the Tables themselves, will form a part of vol. vi. of the *Annales de l'Observatoire Impérial de Paris*; but an outline of the principal results of M. Le Verrier's theoretical investigation appeared in the *Comptes Rendus* for 1860, Nov. 26. Its most remarkable feature is the confirmation it gives to a former inference of M. Le Verrier's, when discussing the lunar equation in the Earth's longitude, viz., that the received value of the Earth's mass is too small by a *tenth* part, and therefore the solar parallax as determined (under

doubtful circumstances) from the transits of *Venus* in the eighteenth century, will require a notable augmentation. On this subject the author observes that in consideration of its serious importance and delicacy, he contents himself at present with having added to the data previously in our possession for resolving the problem of the determination of the planetary masses, and before drawing a definite conclusion will await the completion of the theory of *Mars* upon which he is now engaged, and which will afford a third determination of the value of the Earth's mass. It must be admitted that M. Le Verrier's elaborate researches have added greatly to the interest always attaching to the question of the amount of solar parallax. M. Le Verrier having had the courtesy to forward copies of the tables of *Venus* to the Superintendent of the *Nautical Almanac* in anticipation of the time of their issue to the public, the ephemeris in the forthcoming volume for 1865 will be founded upon them.

Papers read before the Society from February 1860 to February 1861.

1860.

- Mar. 9. On the Luminous Intensity of the Centre of the Sun. M. Chacornac.
 Ephemeris of Variable Stars for 1860. Mr. Pogson.
 On a Mode of getting rid of Personal Equation. Col. Shortrede.
 Notes on Auroral Phenomena. Lieut. Chimmo.
 On Phenomena connected with a Transit of *Jupiter's* third Satellite. Mr. Prince.
 Star Occultations and Lunar Eclipse observed at Hartwell. Mr. Pogson.
 On some previous Transits of Dark Bodies over the Sun. Mr. Carrington.
 Proposed new Design for Vertically Placed Transit Circles. Mr. Carrington.
 Note on an Eye-piece. Mr. Carrington.
 Formulæ for the Reduction of Pastorff's Solar Observations. Mr. Carrington.
 Extract of a Letter to Mr. Carrington. M. D'Abbadie.
 On Future Observations of *Vulcan*. M. Radau.
 On the Heat engendered by the Fall of a Meteor into the Sun. Mr. Waterston.
 On the Variability of the Proper Motion of *Sirius*. Rev. R. Main.
 Occultations of Stars by the Moon. Mr. Airy.

- Mar. 9. Tables of the Developments of Functions in the Theory of Elliptic Motion. Mr. Cayley.
Occultations of Stars by the Moon. Mr. Burr.
Morning Illumination of the Lunar Crater *Hippalus*. Mr. Birt.
On the Total Solar Eclipse, July 18, 1860. Mr. Airy.
- April 13. Observations of Small Planets. Mr. Airy.
Observations of *Hygeia* and *Urania*. M. Lepissier.
On an Appearance in *Jupiter*. Mr. Long.
On the Performance of Mr. Fletcher's new Equatoreal. Capt. Jacob.
On the Parallax of α *Herculis*. Capt. Jacob.
On the Appearance of *Jupiter's* third Satellite on its Disk. Capt. Noble.
Extract of a Letter to Mr. Carrington. Lieut. Gilliss.
Note on one of the Companions of σ *Orionis*. Rev. T. W. Webb.
Suggestions for a true Estimate and Register of the Colour of the Stars, &c. M. Drach.
On the Projection of *Saturn* on the Dark Limb of the Moon. Rev. B. Powell.
On the Appearance of *Jupiter's* Satellites while Transiting the Disk of the Planet. Rev. W. R. Dawes.
On the Figure of the Earth. Capt. Clarke.
Observations of Minor Planets. Mr. Pogson.
Reply to various Objections which have been brought against his Theory of the Secular Variation of the Moon's Mean Motion. Mr. Adams.
Solar Spots in High Latitudes. Mr. Carrington.
On the Secular Variation of the Moon's Motion. Rev. R. Main.
On the Appearance of *Jupiter*. Mr. Airy.
On the Satellite of *Saturn* "*Mimas*." Rev. W. R. Dawes.
- May 11. Catalogue of Positions, &c. of 398 Double Stars. Lord Wrottesley.
On the Problem of the Rotation of a Solid Body. Mr. Cayley.
Note on Mr. Pollock's Communication, No. 29. Mr. Airy.
On the Lunar Acceleration. M. Delaunay.
Apparent R.A. of the Moon's Limb observed at Washington. Lieut. Maury.
Observations of Minor Planets. Mr. Airy.
Note on the Lunar Acceleration. M. Pontécoulant.
Observations of *Hyperion*. Mr. Lassell.
Note on some Variable Stars of unknown or uncertain Period. Mr. Pogson.

- May 11. Observations of Minor Planets. Mr. Airy.
 On the Value of the Constant of Aberration. Rev. R. Main.
 Observations sur les Formules employées jusqu'à présent pour déterminer par la Théorie le Coefficient de l'Équation Séculaire du Moyen Mouvement de la Lune. M. de Pontécoulant.
 On the supposed Variability of the closest Companion of α Orionis. Rev. W. R. Dawes.
 Morning Illumination of part of the *Mare Imbrium*. Mr. Birt.
- June 8. Postscript to Reply to M. de Pontécoulant. Mr. Adams.
 On Projection in Lunar Occultations. Rev. T. W. Webb.
 Occultation of *Jupiter* by the Moon. Capt. Noble.
 Observations of Donati's Comet. Sir T. Maclear.
 Comparison of Burckhardt's and Hansen's Lunar Tables with Greenwich Observations from 1847 to 1858. Mr. Airy.
 Notes of Errors in Mr. Baily's Tables and Formulæ. Mr. Farrell.
 Occultation of *Jupiter* by the Moon. Mr. Gaunt.
 On Ancient Assyrian Observations of *Venus*. Rev. Dr. Hinckes.
 On the Importance of making Observations on Thermal Radiation during the coming Eclipse of the Sun. Prof. Thompson.
 Occultation of *Jupiter* by the Moon. Mr. Airy.
 Réponse aux Observations présentées par M. Adams sur différentes Objections élevées contre sa Théorie de l'Accélération du Moyen Mouvement de la Lune. M. de Pontécoulant.
 Elemens de la Comète decouverte à Olinda le 26 Fevrier, 1860. M. Liais.
 Occultation of *Jupiter* by the Moon. Mr. Burr.
 On a Grey Stripe eastward of Lunar Crater *Geminus*. Mr. Birt.
 Note on the History and present Condition of the Problem, "To find the Latitude by Observations of the Pole Star at any time." Mr. Riddle.
- Nov. 9. Développement de la Fonction Perturbatrice en Série. M. Kowalski.
 Observations taken at Redhill on the 18th July, 1860. Mr. Carrington.
 On the Lunar Theory. Sir John Lubbock.
 Observations of a Comet made in Australia. Mr. Scott.
 Observations of Comet III. 1860. Mr. Ellery.
 Approximate Elements of Planet $\odot$. Mr. Ellis.

- Nov. 9. Observations of the Moon and Moon-culminating Stars at Victoria. Mr. Ellery.
 Elements of Comet II. 1860. Mr. Seeling.
 New Variable Star in *Ophiuchus*. Mr. Pogson.
 Solar Eclipse, July 18, 1860. Mr. Morton.
 Ditto ditto Capt. Noble.
 Ditto ditto Mr. Burr.
 Ditto ditto Mr. Chalmers.
 Ditto ditto Mr. Prince.
 Ditto ditto Mr. Stothard.
 Ditto ditto Mr. Riddle.
 Ditto ditto Rev. Geo. Fisher.
 Ditto ditto Mr. Janson.
 Ditto ditto Rev. W. R. Dawes.
 Observations of a Comet. Mr. Stothard.
 Ditto ditto Col. de Rottenburg.
 Ditto ditto Mr. Clark.
 Note accompanying Lithograph of Nebula. Mr. Lassell.
 Observations of a Comet at Sea. Mr. Krabbe.
 On the Duration of Twilight at Toulouse. Mr. Petit.
 Sun-spot Observations connected with the late Solar Eclipse. Prof. Smyth.
 Elements and Ephemeris of Planet $\odot$. Mr. Ellis.
 On the Magnitudes of the Asteroids. Mr. Pogson.
 Changes in 808 *Messier*. Mr. Pogson.
 Observations of Solar Eclipse, July 18, from Hudson's Bay. The Hudson's Bay Company.
 On a Photograph of the Sun. Prof. Challis.
 Solar Eclipse, July 18, 1860. Mr. Airy.
- Dec. 14. On some Formulæ relating to the Variation of the Plane of a Planet's Orbit. Mr. Cayley.
 Observations of Solar Spots, with Drawings. Rev. Mr. Howlett.
 Solar Eclipse, July 18: Photographs taken in Spain. M. Aguilar.
 Observations on Solar Spots and Temperature. Mr. Hockley.
 On a Method of determining Longitude by means of Observations on the Moon's greatest Altitude. Mr. Spottiswoode.
 On the Motion of the Solar System and Distribution of Perihelia of Comets in relation thereto. Mr. Carrington.
1861.
 Jan. 11. Results of Meridional Observations of Small Planets. Mr. Airy.
 Note sur les Inégalités Lunaires à longues Périodes dues à l'Action Perturbatrice de *Vénus*. M. Delaunay.
 On three new Variable Stars. Mr. Baxendell.

- Jan. 11. On the Revolutionary Velocities and Distances of the Planets. Mr. Glennie.
Addition to Paper, No. 134, "On the Lunar Theory."
Sir J. Lubbock.
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List of Public Institutions and of Persons who have contributed to the Society's Library, &c. since the last Anniversary.

Her Majesty's Government.
The Lords Commissioners of the Admiralty.
The Secretary of State for India.
The Postmaster-General.
Committee of Council on Education.
Royal Society of London.
Royal Asiatic Society.
Royal Geographical Society.
Royal Society of Edinburgh.
Royal Dublin Society.
Royal Institution.
Geological Society.
Linnean Society.
Zoological Society.
Photographic Society.
Society of Arts.
British Association.
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L'Académie Impériale des Sciences de l'Institut de France.
Le Dépôt Général de la Marine.
Le Bureau des Longitudes.
The Society at Cherbourg.
L'Académie des Sciences, Montpellier.
L'Académie des Sciences, Dijon.
Imperial Academy of Vienna.
Royal Academy at Berlin.
Royal Observatory at Munich.
The Society of Physics at Berlin.

Royal Academy of Sciences, Brussels.
 Royal Observatory, Brussels.
 The Society at Leipsig.
 The University at Göttingen.
 La Société de Physique, &c. Geneva.
 The Academy of Sciences, Stockholm.
 Royal Academy of Sciences, Amsterdam.
 Society of Sciences, Batavia.
 Royal Academy of Sciences, Copenhagen.
 Imperial Academy, St. Petersburg.
 Imperial Observatory, Poulkowa.
 Observatory, Dorpat.
 Observatory, San Fernando.
 Royal Observatory, Madrid.
 Musico Fisico, Florence.
 The Institute, Bologna.
 Royal Academy of Sciences at Turin.
 Philosophical Institute of Victoria.
 The Department of State, Washington.
 American Philosophical Society.
 American Academy of Arts and Sciences.
 Smithsonian Institution.
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 The Franklin Institute.
 The Canadian Institution.
 The Editor of the Athenæum.
 The Editor of the Literary Gazette.
 The Editor of the Critic.
 The Editor of the Atalantis.
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*Address delivered by the President, the Rev. Robert Main,
on presenting the Gold Medal of the Society to M. Hermann
Goldschmidt.*

Gentlemen,—In the Report which has been read to you, you have been informed that the Gold Medal of the Society has been this year awarded by your Council to M. Hermann Goldschmidt, for his discoveries of thirteen small planets, and other astronomical works, and the duty devolves on me to explain to you the grounds of this award. This duty, though not necessarily an annual one, has become so in fact, on account of the activity with which the various branches of astronomy have been for many years cultivated, and the undeniable claims which some one or other of our members or associates has established by eminent services or contributions to the science. In fact, I find that since the year 1848 (memorable for our recognition of the eminent claims of no fewer than twelve astronomers, by the award of a Testimonial to each), there has not passed a single year in which the Gold Medal has not been awarded, and I am certain that few persons would be found at the present time who would venture to deny either the justice or the prudence of the award in each individual case.

And, on looking at the list of subjects, one is rather tempted to admire the profusion of talent and the amount of industry which are exhibited in the various works for which the Medal has been awarded, and at the mass of labour in every department of our science which has been thus brought under review before us, and, of necessity, analysed in our meeting-room. The memoirs which have been crowned by us relate in some

instances to the closet labours of the theoretical or the physical astronomer, and in others to the work of the practical observer. In one year we have to reward a brilliant discovery, the result of years of profound study and analytical investigations; in another, the patient labours of an amateur astronomer, who, at his own cost, has produced a copious and valuable catalogue of stars. Sometimes it is a literary work, as the *History of Physical Astronomy*, which has claimed the award; at others, the corrections of some of the most important astronomical elements by a skilful employment of high mathematical attainments on the results of observations.

But, amongst the claims based on discoveries, none have been more frequent of late years than those arising from the addition of new members of the solar system, especially in the remarkable group of planets which lie between the orbits of *Mars* and *Jupiter*. At the commencement of the year 1845, four only of these small bodies were known, and those had been discovered for nearly half a century without receiving any addition to their number: at the present time their number amounts to sixty-two.

In four instances already have the rewards of this Society been bestowed for discoveries of some of these small planets; and the claims are each year becoming greater, and to such an extent, as to demand an explanation why, when there have been and are still so many successful labourers in this field of research, we have selected one amongst them as particularly deserving of the Medal on the present occasion? To this it might be replied immediately, that M. Goldschmidt has laboured more successfully than his competitors, and that the addition of thirteen new members to the solar system is a fact so remarkable in itself and so honourable to him, as to place him beyond the reach of competition, and to give him so high a rank amongst the benefactors of science, as to make the bestowal of our Medal only a fitting mode of expression of our sense of his great merits.

And, indeed, this is strictly and literally true, and there is probably no single name amongst the astronomers who have distinguished themselves during the past twenty years which stands so high in the list of discoverers. But relative merit is, after all, not a ground for the award, and it will be necessary to go rather more deeply into the history of this branch of discovery before I can confidently appeal to your own judgments in corroboration of that of your Council in making this award.

Omitting the history of the first four of the small planets which were discovered at the beginning of this century, it will be necessary to recall to your recollection that the next discoverer was M. Hencke, of Driessen, who, in 1845, discovered *Astræa*, under circumstances as meritorious as are those which I shall have presently to point out to you in the discoveries

of M. Goldschmidt. To this discovery I attach very great weight, as regards the merit of the discoverer; and I would express my opinion that, by originating this branch of research in connexion with the Berlin maps, M. Hencke's claims are of a higher order than those of all who have successfully followed in his steps, and that, if your Council had not already recognised them by the bestowal of a reward, it would be, even at this distance of time, necessary to do so. It must, in fact, be remembered in connexion with those discoveries, that, after M. Hencke, there has been no novelty in the method of search employed. In the greater number of instances the Berlin maps have been employed; and the necessity of this mapping of the stars for facilitating future discoveries has reacted most advantageously on the progress of sidereal astronomy, and has been the chief cause of that accurate survey of the Northern heavens which is now all but perfect. As an honourable example of this kind of research, and of the clearness of view which led to it, I may mention Mr. Bishop's Ecliptic Charts, completed by Mr. Hind,—a work in itself most meritorious and useful, and rewarded at the time by several brilliant discoveries. Another great work of the same kind which must be mentioned is the series of Star-Catalogues of Mr. Cooper, in connexion with which we may mention the discovery of *Metis* by Mr. Graham.

Here, then, Gentlemen, we have at once a definite ground for the encouragement of this branch of discovery, in its intimate connexion with the advancement of sidereal astronomy; and I think we may venture to say, that any one who will undertake the labour of constructing a map of stars as low as the 10th magnitude, for a zone of the heavens of moderate extent not very far from the ecliptic, will, as a matter of course, be rewarded by planetary discoveries. The sweeping of the heavens for stars and the search for planets, if properly conducted, may form one and the same operation; and when we reward the results of such work, we may do so quite independently of any consideration of the value of the planetary discoveries in themselves, though, as I shall try to show, this consideration is also in itself of very great importance. On the other hand, the verification of existing maps, such as the Berlin charts, by frequent and laborious comparison with the heavens, even if the object be not the construction of a new map, is of itself highly important and meritorious, and has led to the rapid increase of discoveries in a branch of the science formerly but little studied, namely, that of variable stars. In these discoveries M. Goldschmidt has also taken a part. It is clear, therefore, that discoveries of small planets are so connected with the extension of other branches of astronomy, that they are in the highest degree deserving of encouragement; but it is equally clear that, in estimating the merit of such

work, our attention must not be fixed chiefly upon that which first attracts the applause of the uninstructed public — that is, upon the brilliancy of the discovery as such — but upon the amount of good and useful work well directed which it puts in evidence in connexion with sidercal astronomy.

Now, the work itself is of a nature to attract to it young astronomers of unbounded energy and zeal, as offering the best chance of success and distinction at an early period of life. The labour is severe, but the reward of perseverance is literally certain, and, as a consequence, a great number of competitors — thirteen, in fact — have won laurels in this field. This gives an average number of nearly five discoveries to each person; but, as usual, the rewards of labour have been very unequal, so that, while M. Goldschmidt has discovered thirteen planets, five of the aspirants have discovered only one each.

Next to M. Goldschmidt, the most successful have been Mr. Hind, M. R. Luther of Bilk, M. De Gasparis,* and M. Chacornac, who claim respectively ten, nine, seven, and six of the planets. Of others, Mr. Pogson has discovered three and Mr. Ferguson also three. M. Hencke discovered two, while Messrs. Graham, Laurent, Marth, Searle, and Forster, have each discovered one. The above statement, if we include the four more ancient small planets, accounts for the whole number, sixty-two, at present known.

The work, then, which M. Goldschmidt has accomplished is, in its cumulative aspect, a great work — greater, perhaps, than has yet fallen to the lot of any other observing astronomer. If we regard the discoveries individually, they are, as I have explained, not of that original or brilliant character which stamp some of the other great discoveries of this age; they are within the scope of most men of energy, who are gifted with sharp eyes, and capable of enduring the fatigue of long watching and examination of the heavens; but, conducted as they have been by M. Goldschmidt for eight years with scarcely any intermission, and resulting in the addition of so many new bodies to our known solar system, they are admirable, and rank their discoverer amongst the first observers of his age, and distinguish him as a man of whom France and Frenchmen may be proud.

Thus far, Gentlemen, I have abstained from saying anything of the means at the disposal of M. Goldschmidt for making these discoveries. I have allowed you to suppose, if you are not acquainted with his history, that he was at least upon a level in point of equipment with his rivals, some of whom (though not all) had the use of large telescopes in fixed observatories. Indeed, the apparent magnitudes of the planets

* The number discovered by M. De Gasparis is now eight.— *Ed.*

discovered would seem to make some such supposition necessary. For example, *Lutetia*, the planet first discovered by him in 1852, he estimated at the 9-10 magnitude; and I am sure it would not have occurred to any of us professional astronomers that such an object was likely to be looked for with success with any object-glass less than 4 or 5 inches. Well, Gentlemen, the telescope with which he made this discovery, by the help of the Berlin star-maps, was of 23 lines aperture, or rather more than 2 inches; such a telescope, in fact, as you see frequently at watering-places for observations of ships and sea-side objects, but such as was perhaps never before used for the discovery of a planet. But this telescope was one of which the young astronomer might well be proud. It, or a smaller one of 19 lines aperture, which it replaced, was purchased with the money obtained for one of two copies which he had made at Florence of the portrait of Galileo. Never, perhaps, were great results accomplished by so small means as were at his disposal; and if this be, as is generally believed, an attribute of genius, M. Goldschmidt may fairly claim the admiration which is due to it. A telescope of 2 inches aperture, placed in the window of a garret forming the sleeping apartment of the astronomer, is made, by judicious handling and severe scrutiny of the Berlin maps, to discover one of a class of objects which it taxes to the utmost the astronomers of Greenwich to observe, when found, with the great transit-circle. But better days were in store for the Astronomer. His next four discoveries—those, I mean, of *Pomona*, *Atalanta*, *Harmonia*, and *Daphne*—were made with a larger telescope; how obtained I am not able to tell you, excepting that it was certainly out of the fruits of his industry in his professional employment as an historical painter, and by the practice of the most rigid economy. Well, Gentlemen, this telescope, undoubtedly an improvement on the preceding, was of 30 lines, or $2\frac{3}{4}$ inches aperture, and with this still apparently inadequate instrument did he discover four additional planets. The remaining eight were discovered with a telescope of 4 inches aperture, and I wish I were enabled to give you some information about its acquisition. Let it suffice that none of them were mounted equatorially, but that, in the greater number of instances, they were pointed out of a window which did not command the whole of the sky; and I now leave you to form your own opinion of that fertility of invention and resource, that steady determination to conquer apparently insurmountable difficulties, the untiring industry, and the never-failing zeal, which realised such splendid results with such inadequate means.

I purposely kept out of sight all these interesting circumstances in the personal history of M. Goldschmidt, till I had led you dispassionately to consider the real value and merit of his discoveries independently of them, and his absolute superiority over his formidable rivals in the race of discovery;

because I consider it as a rule to be adhered to with the utmost tenacity in the bestowal of your Medal — a rule from which, indeed, your Council has never deviated — that the merit and the importance of the astronomical work which we propose to crown with our award must be considered apart from all personal considerations. Indeed I may say with perfect truth, that, to the best of my knowledge, no member of the Council, including myself, was aware of these circumstances; we knew solely that by profession M. Goldschmidt was an artist, but of his peculiar struggles and difficulties in achieving so great astronomical success we were all profoundly ignorant. But surely, Gentlemen, after that we have performed with the utmost rigour and impartiality our duty as astronomers, we may now at least indulge our natural feelings as men, and show before Europe, and especially before France, how we honour the character of him who, both in his scientific and his private capacity, has added to her fame, and who deserves from her such recognition as she so well knows how to give to her illustrious citizens.

It is now time that I turn from the consideration of the discoverers of these new members of our solar system to the results of their discoveries; and, in the first place, I wish I could tell you that through their means we had arrived at some definite theoretical conclusions regarding their origin and their mutual connexion with each other: but such is far from being the case. Isolated from all the greater planetary bodies, they form a ring of planets evidently belonging to a distinct system, and, it may be, having their origin in some great catastrophe countless ages ago. The idea of Olbers, that they were the shattered fragments of some large planet which once glittered in the sky like *Mars* or *Jupiter*, was poetically grand; and the hypothesis, in connexion with Bode's empirical law, was so plausible that even now many cling to it, and try to force facts into accordance with it. But the greater the number of discoveries, the less appearance of truth is there in the hypothesis. In a recent number of the *Nachrichten** is a notice of a paper by Mr. Newcomb, an American astronomer (published originally in the *American Philosophical Transactions*), in which he has arranged and discussed twenty-five of the orbits with reference to the hypothesis of a shattered planet, and he finds nothing whatever to justify this supposition. On this head let us be contented that Bode's law has done its work well: it set astronomers on the true trace for the discovery of the members of this singular system, and it helped to discover *Neptune*. Whether there be a correct law of planetary distances, of which this is a first approximation, or whether the planets have been placed arbitrarily at distances subject only to the ultimate laws of the Almighty Architect,

* No. 1238.

whose designs are unfathomable by us, remains still to be proved. Let it suffice, that in every new discovery we see an additional proof of the wonderfully simple and comprehensive law of gravitation; and that the filmy, vaporous masses of the comets, and these minute atoms, revolve in their appointed courses as unerringly as the ponderous masses of the larger planets.

There is one more consideration which I must lay before you, and it bears the same relation to the subject-matter of this address that the charitable appeal at the end of a sermon does to the theological arguments which may have preceded. I have to ask your assistance and advice with regard to these small members of the solar family. One has already, for want of needful care, gone astray, and, it is to be feared, will not be brought back to the path of rectitude in her orbit: *Daphne* is lost, and, as the numbers increase and the difficulty of providing for the observations and for the computation of the orbits increase in the same proportion, we must fear that other losses will follow, and the results of some of these interesting discoveries be neutralised. This difficulty is not felt now for the first time; and indeed, some few years ago, when the number of planets was comparatively small, an arrangement was made by the directors of several European and American Observatories to divide among them the labour of observing, each Observatory making itself responsible for a definite number of the planets, according to its observing force and instrumental equipment. I am not quite sure that this organisation is understood to exist at the present time: some members of it, at least, have ceased to take part in the operations, and the immense increase of the number of objects to be observed of itself makes it necessary that it should be reconstituted.

But the deficiency of observers does not form the chief difficulty of the case. By judicious arrangements, an association similar to that which I have mentioned, but established on a more permanent plan, and with officers charged with the duty of attempting to keep it in a condition sufficiently vigorous to meet all exigencies arising from the progress of discovery, could be formed without much difficulty; and I have no fear but that the increase of instrumental means and of observing force will, on the whole, keep pace with the progress of discovery. Several large telescopes are mounted equatorially, both in Europe and America, which do but little work, and they could not be better employed than in taking a share in the operations of the proposed association. The deficiency of observing power is, therefore, not an insuperable difficulty: the difficulty is rather to provide systematically for the calculation of the orbits, and the computation and distribution of ephemerides for the use of the observers, as soon as possible after the discovery of a new planet.

It is well known that the Astronomer Royal undertakes

the meridian observations of all those planets which are visible at Greenwich; and this is a most valuable contribution on his part, and a most liberal interpretation of his duties in advancing speculative astronomy. But the difficulty of finding the requisite ephemerides of the daily motions of the planets so embarrassed the observers at Greenwich as at one time to render useless at least half of the observing labour that had been expended. This induced him, as you may remember, to issue a circular addressed to the directors of the chief European Observatories, begging their assistance either in sending recent observations of newly-discovered planets or ephemerides of their motions. This circular was partially successful, and since the time it was issued much less labour is thrown away by the observers.

Still, something more is requisite to meet the present requirements; and all that I can suggest at present is, that the planetary association, when formed, should take the same charge of the computation of orbits and ephemerides as of the observation of the planets. Some Observatories which are not sufficiently well equipped to provide for observations might undertake the discussion of the early observations made by others, while the association might issue specimens of blank forms for the computations, which would make it practicable to put large masses of the work into the hands of comparatively inexperienced computers.

This, however, is not the time to enter into details respecting the plan which I have sketched; and, indeed, a very great deal of thoughtful consideration and discussion must take place before any plan can be devised sufficiently prudent to secure for the present the co-operation which is needed, and to make the proposed association available as a permanent institution.

In the discharge of the duty which has devolved upon me, I have thought it necessary to lay before you the necessity of some speedy mode of vigorous action, being certain that the currency given throughout the world to our Proceedings will at least make it probable that the matter may be taken up by some persons more competent to deal with the difficulty than I can pretend to be.

But, Gentlemen, such is the rate of progress of astronomical discoveries, and so prolific is each individual discovery as containing the germs of many others, or, what is the same thing, so inextricably mingled are the various branches of astronomical research, that our responsibilities do not end with the consideration of any one branch, such as that of planetary discoveries, which we have been considering. The same general survey, or mapping of the Northern heavens, which gave rise to these discoveries, has also advanced, and indeed almost created, another important branch of research, namely, that of variable stars. The number of known variables is now so

rapidly increasing, that provision for the systematic observation of them, and for the discussion of the results, will soon be as necessary as in the case of the small planets. Then, again, the Sun himself presents a rapidly increasing source of interesting matter for research and speculation. The same may be said of the Moon and the great planets, both as regards the analytical investigations relating to the perturbations of their orbits and to their physical peculiarities.

Thus, in whatever direction we turn our eyes, the same remarkable activity and marks of progress are presented to us. Powerful telescopes are continually directed to the heavens in every quarter of the globe, handled by men eager for discovery and intellectually competent to turn to the best account that which they may have discovered or seen. And as, on the earth, each small and apparently rude element teems with organised life, and gives ample employment to the microscope, so do the regions of infinite space, laid open to us by the telescope, in the heavens, teem with unexhausted wonders, which only require the intelligent mind and the keen eye of the astronomer to discover. The works of creation are as boundless at one extremity as at the other. Planets countless in numbers, but which no man has ever seen, probably still roll on in their silent orbits; stars, the centres of other systems as grand and as boundless as all that we behold on a winter night, offer mysterious peculiarities, only waiting for the record of future astronomers; phenomena still more curious than any yet revealed to us are still waiting their scrutiny and development.

Astronomy, after all, is a young science in all the aspects under which we are regarding it; and even at the beginning of the present century, after all the wonderful discoveries of the elder Herschel, not one of the subjects which I have touched on in this address would have found a place. There is no fear for the future, and we may, in anticipation, envy to our descendants the accumulation of facts and the comprehensive grasp which they will have of the science of the visible universe compared with ourselves. It is sufficient for us to know, as astronomers, that there is work—good and well-repaying work—remaining for us to do, and, as Christians and as men, to recognise the scantiness of our knowledge compared with the wonders of creation; and to exclaim with all humility, when we look up intelligently into the starry heavens, “Lord, how manifold are Thy works; in wisdom hast Thou made them all.”

(The President, then delivering the Medal to Admiral Manners, addressed him in the following terms):—

Admiral Manners,—I request that you will have the goodness to transmit to M. Goldschmidt this medal, and to

accompany it with the best wishes of the Members of this Society for his future happiness and prosperity. Tell him how we sympathise with him in his early struggles, and how we admire the energy and devotion which enabled him to accomplish so much with means so utterly disproportionate; and assure him, finally, of the interest with which we shall watch his future career, and of our hope that he may ultimately be enabled to devote exclusively to Astronomy those talents which, under such disadvantageous circumstances, have produced such important results.

The Meeting then proceeded to the election of the Officers and Council for the ensuing year, when the following Fellows were elected :—

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REV. THOS. WM. WEBB, M.A.

Discovery of a New Minor Planet.

A letter has been received from M. De Gasparis, dated Naples, 11th February, 1861, announcing his discovery of a new Planet, of the brilliancy of a star of the 10th magnitude. The position is

	Naples M.T.	App. R.A.	App. Decl.
1861, Feb. 10,	14 ^h 33 ^m 18 ^s .	11 ^h 11 ^m 42 ^s .5,	+ 5° 18' 49".

The comparison was made with 120 Weisse, hora xi., the adopted mean position of this star for January 1861 being

R.A. 11 ^h 8 ^m 28 ^s .93,	Decl. + 5° 14' 24".4.
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The motion of the Planet in Declination is very small ; that in R.A. is about -42^s daily.

ERRATUM.

Vol. xxi. p. 8, *for* June, *read* July in every place where it occurs.

MONTHLY NOTICES
OF THE
ROYAL ASTRONOMICAL SOCIETY.

VOL. XXI.

March 8, 1861.

No. 5.

Dr. LEE, President, in the Chair.

Rev. F. Howlett, Hurst Green;
Edmund Wheeler, Esq., 11 William Street, Upper Hol-
loway;

Capt. H. C. Johnstone, 5th Bengal European Regiment;

Rev. M. A. Smelt, Heath Lodge, Petersfield; and

Andrew Yeates, Esq., 12 Brighton Place, New Kent Road,

were balloted for and duly elected Fellows of the Society.

Note on Prof. Wolf's latest Results on Solar Spots.

By Joseph Baxendell, Esq.

In the "Abstract of his latest Results" (*Monthly Notice* for January 1861), Prof. Wolf announces the law that "greater activity on the Sun goes with shorter periods, and less with long periods;" but with reference to this law, it may be remarked, that although the numbers given by Prof. Wolf indicate a higher range of activity in short than in long periods, they also show that the total amount of action from one minimum to another is not materially influenced by the length of the period. Thus five periods, averaging 9.98 years each, give the mean value of the total amount of action = 449.2; whilst four periods, averaging 12.65 years each, give the mean value = 438.0. The near agreement of these two numbers for periods differing so considerably in length shows that the total amount of action cannot be regarded as being dependent to any great extent upon the length of the period; and it appears, therefore, that the higher range of activity in

short periods is, in fact, due to this near approach to equality in the amount of total action in periods of different lengths. There is, however, a remarkable relation indicated by Prof. Wolf's results which, though not noticed by him, is, perhaps, hardly less important and instructive than the law which he has announced.

If we denote by R the ratio of the intervals from minimum to maximum, and from maximum to minimum, we find that

Five periods, having a mean value of 12.36 years, give $R = \frac{5.12}{7.24} = 0.707$

Five periods, mean value 9.98 years ... $R = \frac{4.54}{5.44} = 0.834$

Five periods, having a mean maximum activity of }
96.12, give ... $R = \frac{3.78}{7.10} = 0.532$

Five periods, having a mean maximum activity of }
62.44, give ... $R = \frac{5.88}{5.58} = 1.053$

Five periods, having a mean total amount of action }
= 544.38, give ... $R = \frac{3.78}{7.10} = 0.532$

Four periods, having a mean total amount of action }
= 319.12, give ... $R = \frac{5.97}{5.55} = 1.075$

The mean value of R from all the periods in Prof. }
Wolf's list is ... $R = \frac{4.83}{6.34} = 0.761$

It appears, therefore, that the value of R is least in long periods and periods of great activity, and greatest in short periods and periods of diminished activity. Variations in the amount or in the maximum intensity of action, have, however, greater influence than changes in the length of the period.

As most of the variable stars have very unequal rates of increase and decrease of brightness, and as the ratio of these rates is also found to be affected by changes in the length of the period and in the range of variation of brightness, Prof. Wolf's results for the Sun give additional importance to the view taken by some astronomers, that the solar spots and the phenomena of the variable stars are produced by similar agencies,

Manchester, Feb. 20, 1861.

On the Persistency during three days of two light Patches on a Solar Spot. By W. R. Birt, Esq.

On the 9th of July, 1860, between 3^h 30^m and 5^h G.M.T., I observed and figured an interesting solar spot on the southern

of the sun, fig. 1. It consisted of a somewhat irregularly shaped nucleus, surrounded by a penumbra, the eastern part of which was the main body by a tongue or spur, and several small spots, and outlines, mostly in the penumbra, the longest diameter of the

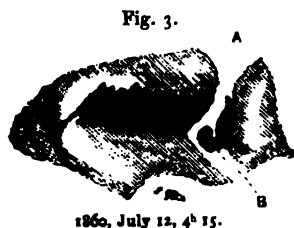
interesting features characteristic of the spot were:—

1. A tongue or spur of a dark convexity being seen, it was *only just* detached from the main body of the nucleus, and only a portion of it.

2. The eastern part of the nucleus, and partially the tongue or spur, a bright patch of light was

seen, that patch of light was noticed north of the nucleus, from the curved portion at a considerable

distance. On July, between 4^h 30^m and 5^h G.M.T., I saw the spot, fig. 2; every portion had undergone a change, the outlines of both nucleus and tongue being altered materially, the surface of the



surface being exceedingly mottled from numerous small bright spots, the spur seen on the 9th of July, as well as the two light patches, A and B, being unchanged both as regarded position and the spot.

On July 12th, from 3^h 30^m to 5^h G.M.T., the spot, except the spur and the tongue, had undergone very remarkable changes, the nucleus being detached, and the spur entirely separated, the appearances of having been subject to a change (fig. 3) at the western extremity of the nucleus, a narrow band of material surrounding it crossed by a narrow line, while the two light patches seen on

the 9th and 11th maintained their positions (A and B, fig. 3), the outline of the penumbra was very irregular, and towards the eastern extremity was broken into several angles, a portion of the penumbra itself being separated from the main body of the spot by the two persistent light patches.

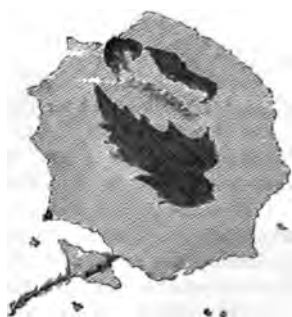
It is not a little remarkable, and a matter that deserves close attention, that while every other portion of the spot underwent considerable change, the two patches of light with the spur maintained at least the same relative positions with regard to each other; observed at first in the eastern portion of the spot, while evidence was afforded of increasingly energetic action by which the nucleus was elongated *westwards* and the penumbra driven in the same direction, the patches of light preserved nearly the same form and inclination to each other accompanied by the spur (a part of the nucleus), which although it did not alter its relative position with regard to them, yet underwent modifications in form which did not appear to affect them. It would seem that from the neighbourhood of the two light patches a force of sufficient energy to extend the spot westwardly was in active operation, while eastwardly the action was confined to modifying the penumbra and altering the form of the spur.

On the Apparent Rotation of a Solar Spot.

By W. R. Birt, Esq.

On the 29th of October, 1860, about 23^h G.M.T., I carefully observed and figured a solar spot, see sketch, fig. 1. The

Fig. 1.



1860, Oct. 29, 23^h 0^m.

Fig. 2.



1860, Oct. 31, 22^h 30^m.

next opportunity I had of viewing this spot was on October 31, about 22^h 15^m, when I again made a sketch of it, see fig. 2.

During the 47 hours and a quarter that elapsed between the two a very considerable change had taken place, and some indications of rotation were afforded.

The spot on the 29th presented a feature by no means rare, viz. the presence of a principal, and also of a secondary nucleus, the breadth by estimation* of the southern or broadest part of the principal nucleus was about 15", the longest diameter being directed towards the north-west, the nucleus ending in a fine point, the eastern side of the nucleus being convex while the western was concave. The secondary nucleus was westward of the principal, irregular in its form, the northern part being curved, the parallelism of the two nuclei was distinctly apparent.

The outline of the penumbra presented the ordinary irregular character, the curved portion of the secondary nucleus and the outline of the penumbra were in contact.

On the 31st, a remarkable change was observed in the two nuclei, the southern portion of the principal nucleus was still the broadest, and occupied much the same position, but the two sides were altered exceedingly, the western side was smoothly convex; and the eastern smoothly concave with a marked protuberance. As on the former occasion the nucleus terminated towards the north in a fine point.

The secondary nucleus had changed its form and position considerably, it appeared as if all its material had progressed so as to have met with such a resistance as to have produced a smooth curvilinear outline, broadest at the front and gradually tapering to a point, the figure strongly suggests the idea of semi-fluidity, the same contact of the penumbral outline with the front of the secondary nucleus observed on the 29th was also seen on the 31st, but in such a position as strongly to suggest a rotation of the entire spot, and also that the secondary nucleus in its motion northward had turned the point of the principal nucleus, the centre of motion being in the neighbourhood of the broadest portion of the principal nucleus.

The longest diameter of the spot was much in the same direction as on the 29th, it however appeared more marked on the 31st, as the spot was foreshortened by its approach to the limb, the parallelism of the two nuclei being very apparent, but not in the direction of the longest diameter of the spot.

On November 1^d 21^h 15^m, G.M.T., I obtained another sketch, fig. 3, of this spot. As it approached the limb, it not only apparently, but I apprehend really, increased in magnitude, the evidence of rotation being still very marked around the southern part of the principal nucleus. It would appear that this part of the nucleus had become broader, the point observed on the two former occasions was blunted and a

* This estimation was obtained by means of an etched glass micrometer, constructed for me by L. Casella, Esq., the value of each division being a little more than 1'.

somewhat thick dark line extended from the principal towards the secondary nucleus, which had evidently increased considerably in size since Oct. 29th. As on the two former occasions the parallelism of the two nuclei was maintained, the farther indication of rotation consisting in the advance of the secondary nucleus in an eastward direction, the whole body of the spot being apparently carried round with it.

On the 31st of October a streak of light divided the penumbra in the neighbourhood of the south-western part of the principal nucleus, this had so considerably increased by November 1^d 21^h 15^m as to leave a portion of the principal nucleus without any penumbral appendage, the contact of the secondary nucleus with the edge of the penumbra being still maintained.

Nov. 2^d 21^h 45^m. Nearly the same features were presented accompanied with an evident arrestation of the rotatory movement, and a very slight divergence from parallelism in the two nuclei. Sketch, fig. 4, exhibits the appearance of the spot at

Fig. 3.

1860, Nov. 1, 21^h 30^m.

Fig. 4.

1860, Nov. 2, 21^h 30^m.

this epoch, and shows the great change that had supervened in the positions and appearances of the nuclei during the 95 hours the spot had been under observation; this sketch is very instructive, and indicates, I apprehend unmistakeably, that the apparent rotation is due to the motion of the secondary nucleus, sketches 2 and 3, exhibiting successive steps in the divergence of the nuclei, a fact spoken of repeatedly by Mr. Carrington. Shortly after the completion of sketch 4 the long thin line nearly connecting the principal with the secondary nucleus was observed breaking up into two or three small

spots; and during the progress of the sketch the penumbra underwent change, several lucid portions within its boundary were noticed near the nuclei, and generally much more energetic action was manifested upon the cessation of the apparent rotatory motion than while it was in progress; there also appeared to be indications of internal curvilinear motion.

An Auxiliary Table for the Easy Calculation of Log. sin. and Log. tan. of Small Arcs. By S. M. Drach, Esq.

The table which I herewith offer to the Royal Astronomical Society has been found by me to be very useful, especially at the beginning of the quadrant, obviating the necessity of interpolations in the ordinary "small arc log. sin., &c." table, and could be appended in detached portions to seven fig. logs. of numbers. Thus to find, by means of it, log. sin. and log. tan. of $7^{\circ} 34'' 82$.

$$\begin{array}{rcl}
 7^{\circ} 34'' 82 & = & 454'' 82 \\
 \text{Log } 454'' 82 & = & 2.6578396 \\
 \text{Tab. 8' sin.} & = & 4.6855745 \\
 \text{log. sin } 7^{\circ} 34'' 82 & = & 7.3434141 \\
 \text{Tab. 8' tan.} & = & 4.6855756 \\
 \text{log. tan.} & = & 7.3434152
 \end{array}$$

But for this purpose the logs. of numbers must be extended to 10800.

A great advantage would result from prefixing a column to the No. in the logs. of numbers indicating the deg. and min. of the No., considered as denoting a number of seconds.*

With such a table the proportional logarithms of nautical tables might be dispensed with, the constant for 3^h or 3° being 10800 or 4.0334238. Thus, suppose the Greenwich three hourly distances of the Moon from a star, according to the *Nautical Almanac*, be $1^{\circ} 12' 21''$, and the observer finds his corrected distance to be $1^{\circ} 4' 12''$, the interval for Greenwich time would be thus computed:—

$$\begin{array}{rcl}
 \text{C. log } 10800 (3^h) & = & 4.0334238 \\
 \text{Subtract log } 4341 (1^{\circ} 12' 21'') & = & 3.6375898 \\
 & & 0.3958340 \\
 \text{Add log } 3852 (1^{\circ} 4' 12'') & = & 3.5846863 \\
 3^h 39^m 21.4 = 9561'' 4 & = & \text{log. } 3.9805203
 \end{array}$$

* This is done at the foot of the page in Bremiker's Tables, Berlin, 1852.—Ed.

The Greenwich interval is then $2^h 39^m 21^s.4$, and the number 3958340 in the *Nautical Almanac* column in lieu of the "P. L. of Diff." (no log. index required), would give nearer results, with the advantage of not changing the formula sine, cosine, &c. to the P. L. cosec., sec., &c.

Auxiliary Table for Small Arcs.

To find the log. sin. or the log. tan. add to the log. number of seconds the number in the column sin. or tan. of this Table. The number to be added commences 4.685, the columns of the Table giving the remaining decimals.

Arc. o ,	No. of Secs.	sin = 4.685 +	Diff.	tan = 4.685 +	Diff.
0 1	60	5748	...	5748	...
2	120	5748	...	5749	...
3	180	5748	...	5750	...
4	240	5748	...	5751	...
5	300	5747	...	5752	...
6	360	5746	...	5753	...
7	420	5746	...	5755	...
8	480	5745	...	5757	...
9	540	5743	...	5758	...
10	600	5742	...	5760	...
11	660	5741	...	5763	...
12	720	5740	...	5766	...
13	780	5738	...	5769	...
14	840	5737	...	5773	...
15	900	5735	...	5776	...
16	960	5733	...	5780	...
17	1020	5731	...	5784	...
18	1080	5728	...	5788	...
19	1140	5726	...	5792	...
20	1200	5725	...	5898	...
21	1260	5722	...	5803	...
22	1320	5719	...	5808	...
23	1380	5716	...	5813	...
24	1440	5713	...	5819	...
25	1500	5710	...	5825	...
26	1560	5707	...	5831	...
27	1620	5704	...	5838	...
28	1680	5700	...	5845	...
29	1740	5698	...	5852	...
30	1800	5694	...	5859	...
31	1860	5690	...	5867	...
32	1920	5686	...	5874	...
0 33	1980	5682	...	5882	...

Arc. ° ,	No. of Sec ^{ds} .	sin = 4'685 +	Diff.	tan = 4'685 +	Diff.
0 34	2040	5678	...	5890	...
35	2100	5674	...	5899	...
36	2160	5669	...	5907	...
37	2220	5665	...	5916	...
38	2280	5661	...	5926	...
39	2340	5655	...	5935	...
40	2400	5651	...	5945	...
41	2460	5646	...	5955	...
42	2520	5641	...	5965	...
43	2580	5635	...	5975	...
44	2640	5630	...	5986	...
45	2700	5624	...	5996	...
46	2760	5619	...	6008	...
47	2820	5613	...	6019	...
48	2880	5607	...	6031	...
49	2940	5602	...	6043	...
50	3000	5595	...	6056	...
51	3060	5590	...	6068	...
52	3120	5585	...	6080	...
53	3180	5577	...	6093	...
54	3240	5570	...	6106	...
55	3300	5564	...	6120	...
56	3360	5556	...	6133	...
57	3420	5550	...	6147	...
58	3480	5543	...	6161	...
0 59	3540	5535	...	6175	...
1 0	3600	5528	...	6190	...
1	3660	5521	...	6204	...
2	3720	5514	...	6220	...
3	3780	5506	...	6235	...
4	3840	5498	...	6251	...
5	3900	5490	...	6266	...
6	3960	5482	...	6282	...
7	4020	5473	...	6298	...
8	4080	5465	...	6315	...
9	4140	5457	...	6332	...
10	4200	5448	...	6349	...
11	4260	5440	...	6366	...
12	4320	5432	...	6384	...
13	4380	5422	...	6402	...
14	4440	5413	...	6419	...
15	4500	5404	...	6438	...
1 16	4560	5395	10	6457	18

Mr. Drach, Auxiliary Table

Arc. ° '	No. of Secs.	sin = 4°685 +	Diff.	tan = 4°685 +	Diff.
17	4620	5385	9	6475	19
18	4680	5376	9	6494	20
19	4740	5367	10	6514	19
20	4800	5357	10	6533	19
21	4860	5347	10	6552	20
22	4920	5337	10	6572	21
23	4980	5327	10	6593	21
24	5040	5317	11	6614	20
25	5100	5306	10	6634	21
26	5160	5296	10	6655	21
27	5220	5286	11	6676	22
28	5280	5275	12	6698	23
29	5340	5263	11	6719	22
30	5400	5252	10	6741	23
31	5460	5242	12	6764	21
32	5520	5230	11	6785	23
33	5580	5219	11	6808	23
34	5690	5208	13	6831	24
35	5700	5195	12	6854	23
36	5760	5184	11	6878	23
37	5820	5172	11	6901	25
38	5880	5161	12	6926	24
39	5940	5149	13	6950	23
40	6000	5136	12	6973	26
41	6060	5124	12	6999	25
42	6120	5112	13	7024	24
43	6180	5099	13	7048	26
44	6240	5086	12	7074	26
45	6300	5074	13	7100	25
46	6360	5061	13	7125	27
47	6420	5048	14	7152	26
48	6480	5034	13	7178	27
49	6540	5021	13	7205	27
50	6600	5008	14	7232	27
51	6660	4994	14	7259	26
52	6720	4980	13	7285	28
53	6780	4967	14	7313	28
54	6840	4953	14	7341	28
55	6900	4939	14	7369	29

Arc. °	No. of Secs.	$\sin = 4'685 +$	Diff.	$\tan = 4'685 +$	Diff.
1 56	6960	4925	15	7398	28
57	7020	4910	15	7426	28
58	7080	4895	14	7454	30
1 59	7140	4881	14	7484	29
2 0	7200	4867	15	7513	30
1	7260	4852	15	7543	29
2	7320	4837	15	7572	30
3	7380	4822	15	7602	31
4	7440	4807	16	7633	30
5	7500	4791	15	7663	31
6	7560	4776	16	7694	31
7	7620	4760	15	7725	31
8	7680	4745	16	7756	31
9	7740	4729	15	7787	33
10	7800	4714	16	7820	32
11	7860	4698	17	7852	32
12	7920	4681	16	7884	32
13	7980	4665	16	7916	33
14	8040	4649	16	7949	33
15	8100	4633	18	7982	33
16	8160	4615	16	8015	34
17	8220	4599	16	8049	34
18	8280	4583	18	8083	33
19	8340	4565	17	8116	34
20	8400	4548	17	8150	35
21	8460	4531	18	8185	34
22	8520	4514	17	8220	36
23	8580	4496	17	8254	35
24	8640	4479	19	8290	36
25	8700	4460	17	8325	36
26	8760	4443	18	8361	36
27	8820	4425	18	8397	36
28	8880	4407	18	8433	37
29	8940	4389	18	8470	36
30	9000	4371	19	8506	37
31	9060	4352	18	8543	37
32	9120	4334	19	8580	37
33	9180	4315	19	8617	38
2 34	9240	4296	18	8655	38

Arc. °	No. of Secs.	$\sin = 4^{\circ}685 +$	Diff.	$\tan = 4^{\circ}685 +$	Diff.
2 35	9300	4278		8693	
36	9360	4259	19	8732	39
37	9420	4239	20	8770	38
38	9480	4220	19	8808	38
39	9540	4200	20	8847	39
40	9600	4131	19	8886	39
41	9660	4161	20	8926	40
42	9720	4141	20	8965	39
43	9780	4121	20	9004	39
44	9840	4101	20	9045	41
45	9900	4081	20	9085	40
46	9960	4061	20	9126	41
47	10020	4041	20	9167	41
48	10080	4020	21	9208	41
49	10140	3999	21	9249	41
50	10200	3978	21	9290	41
51	10260	3957	21	9332	42
52	10320	3937	20	9375	43
53	10380	3915	22	9416	41
54	10440	3894	21	9460	44
55	10500	3873	21	9502	42
56	10560	3851	22	9546	43
57	10620	3830	21	9589	43
58	10680	3807	23	9632	43
2 59	10740	3786	21	9676	44
3 0	10800	3764	22	9720	44

Watford, Herts, March 4, 1861.

*From a Letter from Professor Hansen to the Astronomer
Royal, dated Gotha, 861, Feb. 2.*

(Translated from the German.)

"You express in your honoured letter the wish that I would soon publish the calculation of my Lunar Perturbations, and I can assure you that I myself fully take part in that wish. I am even occupied, as far as my other labours permit, with the performance of this: a work of tolerable size is already finished, and I hope soon to be in a condition to draw up the manuscript for press for the first treatise. As far as I have yet advanced in the new calculations, I have found no differ-

ence from the coefficients used in the Lunar Tables, which amounts to $0''.1$; the new coefficients differ, at the most, from those of the Lunar Tables by a few hundredth parts of a second. My plan in this new investigation of the Lunar Perturbations stands firm, and cannot be altered.

"You wish further to know what I understand by the expression in my letter of 1854, Nov. 3, 'In my Lunar Tables I have provisionally used coefficients, which are not free from some empiricism,' and I will willingly communicate this to you. In the first place, I mean thereby the part of the motion of the line of nodes and of the line of apsides which is proportional to the time itself; and in the next place, the coefficient of the argument $8V - 13E$; nothing further, unless also the determination of the coefficient of the parallactic equation by observations be called empiricism. In order to be able to calculate those coefficients by theory alone, with such accuracy that they could be employed in the tables without anything further, one would be obliged to calculate the coefficients of the periodical perturbations with far greater exactness than is otherwise demanded; and this I considered to be superfluous, as it would have engrossed very much time. For the rest, I have found the coefficient of $8V - 13E$, by my last theoretical determination of it, by no means insensible, like Delaunay. Without the introduction of this coefficient, the observations show deviations at different epochs; but with the introduction of this, these deviations disappeared even to the last trace. I considered, therefore, its introduction as established, and reserve to myself a new theoretical determination of it, but cannot take this in hand until I shall have proceeded further in the new calculation of the remaining coefficients. I have, besides, some other inequalities of long period, which are caused by the planets; but as the coefficients of these inequalities are small, I have neglected them in the tables, in order to avoid too great extension.

"It is probably the recent publication of Delaunay which has led you, most highly-honoured colleague, to the inquiry which I have plainly answered above; and I see myself compelled, in relation thereto, to add that, in the comparison with the observations, I have taken in no old eclipse or other ancient observation. I have never gone beyond Bradley's observations, and nevertheless my tables represent the ancient observations with satisfactory agreement.

"I have already shown that the ancient eclipses cannot be satisfied by the secular variation of Adams and Delaunay (*Comptes Rendus*, tome I. No. 10). I have now made trial of it, omitting the inequality dependent upon $8V - 13E$, but find the effect of this very trifling, and almost the same enormous differences. I would gladly have said nothing of this until my new calculation of the secular variation was finished; but with the inducement which you have given me, I cannot

refrain from bringing forward what I have found about a year ago in relation to this. The method which Messrs. Adams and Delaunay have pursued in the calculation of the secular variation of the moon's mean longitude requires, in the co-ordinates or the elliptic elements of the moon, the introduction of terms of the following form:—

$$a t \frac{\sin}{\cos} \left\{ i g + i' g' + K \right\} + \frac{b}{n} \frac{\cos}{\sin} \left\{ i g + i' g' + K \right\} \dots\dots (A)$$

where a and b are numerical coefficients, i and i' whole numbers, g and g' the mean anomalies of the Moon and of the Sun, K a function of the perihelion and of the nodes, and n the secular mean motion of the Moon. Against this nothing can be said; and Plana and Pontécoulant, who have attacked this principle, are in this respect in error. Methods, indeed, can be given in which the second class of the above-mentioned terms do not come into consideration; but if this matter be treated as Adams and Delaunay have done, these terms must be introduced. But—whence do these terms arise? They arise out of the following terms of the Sun's co-ordinates:—

$$a' t \frac{\sin}{\cos} \left\{ i' g' + \frac{b'}{n} \frac{\cos}{\sin} \right\} i' g' \dots\dots\dots (B)$$

and the method which requires the complete taking into account of the terms (A) requires, of course, also the complete taking into account of the terms (B), and these are not small. The greatest of the coefficients denoted by b' exceeds 90° . Further, the part of the perturbation-function of the Moon depending upon the planets contains terms which may also contribute to the secular variation of the Moon's mean longitude: these are, however, smaller than those above.

"All the memoirs of Messrs. Adams and Delaunay on this matter which have come into my hands I have carefully looked through, but I have not been able to remark that regard had been taken of the above coefficients denoted by b' , or of those depending upon the planets. Until I am convinced of the contrary, therefore, I must assume that these terms have not been taken into account; and I have in this, again, a ground for the suspicion that Delaunay may also have overlooked terms in the latest calculation of the coefficient of $8V - 13E$.

"I can, besides, affirm that even in Adams' first memoir (received and read June 16, 1853) combinations have been overlooked* which, indeed, for the coefficient there calculated, accidentally destroy each other, but whose continued omission must necessarily make the terms of the higher orders incorrect. We find, in the memoir named, in the longitude,

* In the original thus, "die zwar für den dort berechneten Coefficienten sich zufällig aufheben, aber deren fortgesetzte Uebergang nothwendig die Glieder der höheren Ordnungen unrichtig machen muss."—Ev.

$$+ \frac{295}{24} m^2 \frac{e' d e'}{n d t} \cos (2 v - 2 m v) - \frac{413}{48} m^2 \frac{d e'}{n d t} \cos (2 v - 2 m v - c' m v)^* \\ + \frac{59}{48} m^2 \frac{d e'}{n d t} \cos (2 v - 2 m v + c' m v); *$$

while these coefficients are respectively =

$$+ \frac{74}{3} m^2, \quad - \frac{215}{48} m^2, \quad + \frac{257}{48} m^2.$$

In the radius, we there find

$$+ \frac{95}{12} m^2 \frac{e' d e'}{n d t} \sin (2 v - 2 m v) - \frac{133}{24} m^2 \frac{d e'}{n d t} \sin (2 v - 2 m v - c' m v)^* \\ + \frac{19}{24} m^2 \frac{d e'}{n d t} (\sin 2 v - 2 m v + c' m v); *$$

while these coefficients are respectively

$$+ \frac{203}{12} m^2, \quad - \frac{61}{24} m^2, \quad + \frac{91}{24} m^2.$$

"It appears that the combination of the term $3 \frac{d e'}{n d t} \cos c' m v$ with the other entering terms has been overlooked.

"In conclusion, I must remark that I shall never be able to favour the development of the Lunar Perturbations in series according to the powers of m , unless it is proved,

"(1.) That these series converge;

"(2.) If this is the case, that the sum of the undeveloped terms of each one of these series can be assigned with sufficient approximation.

"That the first terms of a series decrease is no proof of the convergence of a series, for many diverging series can be brought forward in which this case occurs. It is also known that in slowly converging series the sum of the small terms not taken into account may often amount to something considerable."

Results of Observations of the Solar Eclipse of 1860, July 18, made at the Royal Observatory, Greenwich, for determination of the Errors of the Tabular Elements of the Eclipse. By G. B. Airy, Esq., Astronomer Royal.

Before leaving the Observatory for observation of the Totality of the Eclipse in Spain, I drew up a set of Instructions

* In Prof. Hansen's manuscript the coefficients of these terms are written $\frac{e' d e'}{n d t}$. — ED.

for observation of the Eclipse at Greenwich, framed with the intention of giving means for ascertaining the errors of all the tabular elements of the Eclipse, namely, the difference of right ascension of centres of Sun and Moon, difference of north polar distance of centres of Sun and Moon, and semidiameters of Sun and Moon. The general scheme was as follows:—

1. From the beginning, at $1^h 38^m$, Greenwich mean solar time, to $1^h 55^m$, observations of the difference of N.P.D. of the cusps were to be made. These would show an effect of excess of Moon's R.A., increased by an excess of sum of semidiameters.

2. From $1^h 55^m$ to $2^h 15^m$, observations of the difference of R.A. of the cusps were to be made. These would show an effect principally of excess of Moon's N.P.D.

3. From $2^h 15^m$ to $2^h 45^m$, observations of the difference of R.A. of the Sun's 1 L. and Moon's 1 L. were to be made. These would show an effect of excess of Moon's R.A., diminished by an excess of Moon's semidiameter, but increased by an excess of Sun's semidiameter.

4. From $2^h 45^m$ to $3^h 20^m$, observations of the difference of N.P.D. of Sun's N. L. and Moon's N. L. were to be made. These would show an effect of excess of Moon's N.P.D., diminished by an excess of Moon's semidiameter, but increased by an excess of Sun's semidiameter.

5. From $3^h 20^m$ to $3^h 53^m$ (the end), observations of the difference of N.P.D. of the cusps were to be made. These would show an effect of excess of R.A. of Moon's centre, diminished by an excess of sum of semidiameters.

The observations No. 5 would form a valuable combination with No. 1, but they were not absolutely necessary. A very slight examination of the scheme will show that Nos. 1, 2, 3, 4, will give all the corrections of elements required.

The observations were made with the Great Equatoreal, under the general superintendence of Mr. Main, by Mr. Carpenter, assisted by Mr. Criswick and junior computers in the reading of microscopes, &c. The observations, Nos. 1, 2, 3, 4, were obtained in full number; the numbers of comparison-pairs being respectively 12, 27, 19, 18; but No. 5 was totally lost from clouds.

The observed measures were compared with the corresponding quantities computed by a laborious process from the places in the *Nautical Almanac*. To every numerical element of the *Nautical Almanac* was attached a symbolical correction, and the multiples of these symbolical corrections, affecting each of the quantities measured (whether depending on cusps or on limbs, and whether in R.A. or in N.P.D.), were carefully computed. Thus the comparison of each measured quantity with the corresponding computed quantity gave an equation containing multiples of all the corrections to elements and one numerical term.

Without entering further into the details (which will more

properly appear in the *Greenwich Observations*) the corrections were found as follows:—

Correction to excess of Moon's R.A. over Sun's R.A.	— 38' 63
Correction to excess of Moon's N.P.D. over Sun's N.P.D.	— 8' 75
Correction to Sun's Semidiameter	— 1' 45
Correction to Moon's Semidiameter	— 2' 97

To these I may add the following:—

Mr. Ellis found, by an imperfect meridian observation of the Sun,—

Correction to Sun's R.A. + 0' 13; to Sun's N.P.D.	— 2' 49
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And, by good altazimuth observations of the Moon,—

Correction to Moon's R.A. — 2' 40; to Moon's N.P.D.	— 4' 57
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Hence,

Correction to excess of Moon's R.A. over Sun's R.A.	— 37' 95
Correction to excess of Moon's N.P.D. over Sun's N.P.D.	— 2' 08

Of the two sets of results, those from the Equatoreal observations are undoubtedly by much the more accurate.

These corrections, it will be remembered, apply to the places in the *Nautical Almanac*; that is, to places computed by Burckhardt's Tables.

From the numbers given by Mr. Hind, in his circulated calculations of the eclipse, it appears that the places of the Moon given by Hansen's Tables, on July 18, 1^h, differ from those given by Burckhardt's Tables, by — 2' 33 in R.A. and — 4" 0 in N.P.D.; and the Moon's semidiameter from Hansen's Tables is less than that from Burckhardt's by 0" 6. Also the places of the Sun given by Le Verrier's Tables differ from those given by Burckhardt's Tables, by + 0' 17 in R.A. and + 0" 8 in N.P.D.; and the Sun's semidiameter from Le Verrier's Tables is less than that from Carlini's Tables by 1" 7. Using these in combination with the numbers above, it appears that the corrections to the results from Hansen's and Le Verrier's Tables were

Correction to excess of Moon's R.A. over Sun's R.A.	— 1' 1
Correction to excess of Moon's N.P.D. over Sun's N.P.D.	— 4' 0
Correction to Sun's Semidiameter	+ 0' 3
Correction to Moon's Semidiameter	— 2' 4

Royal Observatory, Greenwich,
1861, March 6.

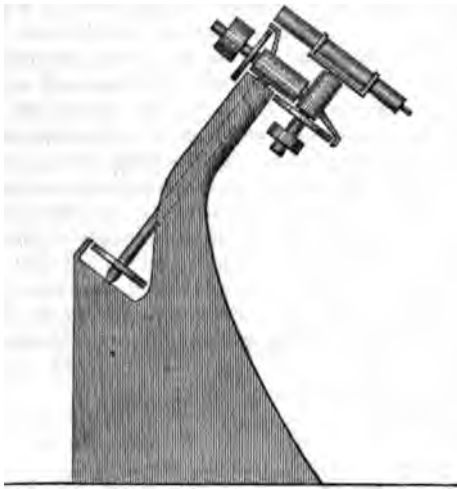
Suggestion of a new Astronomical Instrument, for which the name "Orbit-Sweeper" is proposed. By G. B. Airy, Esq., Astronomer Royal.

In reflecting on the possibility of picking up De Vico's comet, by aid of the sweeping ephemeris prepared by Mr. Hind, I could not but observe how ill adapted for this purpose are the instruments in ordinary use. It will be remarked that, in this and similar cases, it is not a general search in all directions about a given point that is required. For every day, places are computed which lie in a definite line drawn upon the celestial sphere; and, while it may be requisite to sweep many degrees along that line, it will be useless to direct the telescope many minutes above it or below it. The geometrical conception of the matter will at once explain this. The elements of the comet's orbit, considered as a curved line through space of three dimensions, are known with considerable accuracy; but the time of the comet's return to perihelion is not known with accuracy, and therefore the actual place of the comet upon that curved line is not known with accuracy; all that is accurately known being, that the comet will be somewhere on that line. And in fact, the definite line drawn upon the celestial sphere (of which I have spoken) is the perspective representation of a portion of the comet's orbit as viewed at a certain instant of time from the earth; and therefore the optical place of the comet must be somewhere upon that line traced on the celestial sphere, but we cannot say exactly where.

An unmounted telescope can scarcely be used to sweep along a definite track through the sky, which is defined by numerical elements of right ascension and north polar distance, but cannot easily be referred to distinguishable stars occurring in the breadth of every field of view. And the mounting which for all ordinary purposes is the most convenient, namely, that of the equatoreal, cannot be easily applied here. For sweeping in right ascension only, or (with the aid of clockwork movement, which every equatoreal ought to have) for sweeping in polar distance only, it is excellent; but for sweeping in an inclined direction, it is no better than an unmounted telescope.

I have arranged a form of mounting adapted to sweeping in all directions, a model of which (of about half-size dimensions) I ask leave to exhibit to the Society. The general form of the instrument is that of a German Equatoreal. The polar axis is similar to that of a German Equatoreal; but, in order to allow freedom of rotation to all parts, the fixed mass in which the polar axis turns must not be a pier widening downwards from the upper bearing of the polar axis, but must for some distance be a hollow tube or trunk. The cross-axis will be similar to that of a German Equatoreal; but instead of carrying the Telescope, it will carry a small trunk in which a second cross-axis turns.

This second cross-axis carries the Telescope. The polar axis should have a divided hour-circle, and clock-work movement (omitted in the model), the first cross-axis must have a graduated circle, and a clamp or stops by which it may be firmly fixed in a given position; the second cross-axis carrying the telescope must have a graduated circle, and must have two stops limiting its sweeping motion to any arbitrary extent. The second cross-axis must have a counterpoise for the telescope; the first cross-axis must have a counterpoise sufficient to balance both the telescope and the telescope's counterpoise. The annexed figure was drawn from the model.



It will be easily seen that, by giving a proper position in rotation to the first cross-axis, the inclination of the second cross-axis to an astronomical meridian may be made any whatever, and therefore the inclination of the circle in which the telescope will sweep may be made any whatever; and it may be made to coincide with the definite line drawn on the celestial sphere in which the comet is to be sought. And, by means of its stops, the extent of that line through which its sweep is to be made may be limited as we may think fit.

To such an instrument I would propose to attach the name "Orbit-Sweeper."

If I were to construct such an instrument expressly for the purpose of sweeping orbits, I would make it of wood. Such a construction would be more than sufficiently accurate for the purpose in question; its expense would be very small, it would be lighter than metal, for the same degree of stiffness; and its counterpoises, &c. would be light.

But it would be easy to adapt a common German Equatoreal to the same purpose, if the support of the polar axis widened out so little as to allow the telescope-counterpoise on the second cross-axis to rotate round it (for which purpose it might be worth while to substitute a trunk-support, as is described above). The possible inconveniences would be, that the counterpoises would be rather heavy, and that there might be a little instability from the use of three axial movements instead of two. The ordinary use of the Equatoreal would in no way be impeded.

There is one special application of such an instrument which deserves notice. It is known to lunar-observers and to lunar-photographers, and to none better than to some of the active members of this Society, how difficult it is to follow the Moon with an equatoreal. Now it is easy to compute the Moon's apparent motion in right ascension and north polar distance (both corrected for the continued change of parallax), and therefore to compute the inclination of the Moon's apparent orbit through the sky; and to this the Orbit-Sweeper might be at once adjusted. It would be equally easy to compute the Moon's apparent velocity in that orbit; and there must be a special clock movement, acting on the clamp of the circle of second cross-axis, with the proper speed; there would be little difficulty in arranging this. Thus I anticipate that a given spot on the Moon might be automatically kept for a long time under the cross wires of a telescope without discoverable motion.

*Royal Observatory, Greenwich,
March 6th, 1861.*

Mr. C. V. Walker received from the Astronomer Royal, and with his permission communicated to the Society, some letters and a paper on Controlling Clocks by Electricity.

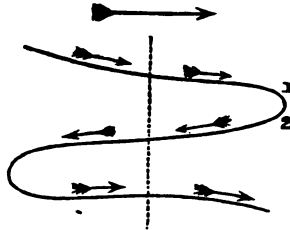
In a letter, dated 18th Feb. 1861, Mr. Airy writes:—

“I have been reading your interesting account of the time-signal operations, which will convey a great deal of information to the public.

“In regard to the interruption of the duration of action of the foreign current upon the pendulum, I think it will not succeed, for the following reason:—Let the curve which follows be understood to represent the pendulum-oscillations, the uniform course of time being downwards, and the direction of motion of the pendulum being shown by the arrows. Also, let the external arrow show the direction of the foreign force. The figures 1 and 2 merely show which part of the swing is, 1 towards the right and 2 towards the left.

“Now the rule for efficiency of external force in maintaining

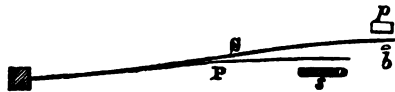
pendulum-motion is this:—If the direction of force agrees with the direction of motion, it maintains the vibration; if it is opposed, it diminishes the vibration. Thus, if the external



force act during any part of 1, it maintains the vibration; if during any part of 2, it diminishes it; if equally on both, it produces no effect.

“Now any ordinary spring-contact that your pendulum can make will equally affect 1 and 2, and therefore will not serve. It will expose you as much to the chance of force opposing the vibration as of force assisting the vibration.

“Possibly you may do it in some such way as this:—



S, Spring.

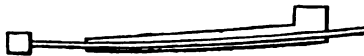
P, Passing spring.

s, Pendulum stud.

b, Banking pin.

p, Piece carried by a spring for contact,

the arrangement of spring and passing-spring exactly as in my 10-inch clock; the form of the passing-spring, as you look from above, being



Then the pendulum-stud, in swinging to the right, will lift the passing-spring and the spring to contact, but will let it snap down before the end of vibration. In swinging to the left, it will press the passing-spring only down, and at last let it snap up.

“The spring-work must be very light.”

And with a subsequent letter, dated the 20th Feb., was sent a paper containing the theory of the subject, as follows:—

Theory of the Regulation of a Clock by Galvanic Currents acting on the Pendulum. By G.B. Airy, Esq., Astronomer Royal.

I. Effect of force upon a pendulum.



The long curve is supposed to represent the swing of the pendulum; and the long arrows represent the direction of its swing. The short arrows represent the direction of a galvanic force, and the place of the pendulum when the galvanic force is acting.

At No. 1	the force quickens the rate most,	does not alter the arc,
2	— quickens the rate,	increases the arc,
3	— does not alter the rate,	increases the arc most,
4	— retards the rate,	increases the arc,
5	— retards the rate most,	does not alter the arc,
6	— retards the rate,	diminishes the arc,
7	— does not alter the rate,	diminishes the arc most,
8	— quickens the rate,	diminishes the arc,
1	— quickens the rate most,	does not alter the arc.

If the galvanic force act the opposite way, the figure may be turned round the vertical line in its own plane, so as to reverse the figure in regard to right and left, and every remark is still correct.

II. In applying this to the regulation of a clock, it must be borne in mind,—

1st. As it is essential that the clock should continue to go (though erroneously) when the galvanism is accidentally interrupted, the galvanic force is always to be supposed subordinate to the maintaining power in the clock.

2d. The galvanic force must be large enough to do its duty of regulation, and, therefore, when applied at the most favourable place (No. 1 or 5, as the case may be), the galvanic force must be too large and must overdo the regulation.

III. Hence, considering the different cases,—

(A.) Suppose the pendulum (which is to be regulated) to go, by its own motion in connexion with its own clock, slower than the regulating clock.

We now want to quicken the rate. Start the clock, therefore, so that the galvanic force acts at No. 1.

By the remark II. 2d, this force will over-accelerate the

rate. In a short time, therefore, we shall have the action at No. 2. Here the rate is quickened in a minor degree, and the place of No. 2 will change till it is quickened exactly in the proper degree. At the same time the arc is increased, i. e. the maintaining power is increased, and there is no fear of the clock stopping. This will do.

If we had started the clock for force at No. 5, it would have gone through the stages 4, 3, to 2. This will do, but the process will, perhaps, be a little longer. There is no fear of the clock stopping.

(B.) Suppose the pendulum which is to be regulated to go quicker than the regulating clock.

We now want to retard the rate. Let the force act at No. 5. This will over-retard the rate, and will bring it gradually to the state 4, where the retardation is exactly correct. The maintaining power is increased. This will do.

If the force had acted at No. 1, the rate would have been much accelerated, and we should quickly have had the states 2, 3, 4. There is no fear of the clock stopping.

If we started the clock in the state 7, we might run the risk of stopping it.

IV. Hence the following rule appears to be sufficient, in addition to II. (1st) and (2d):—

Start the clock so that the force acts at either extremity of the swing. In case (A) it will soon come to state 2, and will stop there; in case (B) it will soon come to state 4, and will stop there.

Results of the Observations of Small Planets made with the Transit-Circle; and Eclipses, Occultations, and Transits of Jupiter's Satellites; observed at the Royal Observatory, Greenwich, during the months of January and February, 1861.

(Communicated by the Astronomer Royal.)

(All observations of N.P.D. are corrected for Refraction and Parallax.)

Hebe (6).

Mean Solar Time of Observation.			R. A. from Observation.	N. P. D. from Observation.
	^h	^m ^s	^h ^m ^s	[°] ['] ^{''}
1861, Feb. 25	12	57 35.9	11 21 2.54	75 34 52.78
28	12	43 16.3	11 18 30.30	75 4 25.76

Parthenope (11).

Mean Solar Time of Observation.			R. A. from Observation.	N. P. D. from Observation.
	^h	^m ^s	^h ^m ^s	[°] ['] ^{''}
1861, Feb. 28	13	7 0.5	11 42 18.41	82 37 18.52

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Flora (5).

Mean Solar Time of Observation.				R.A. from Observation.			N.P.D. from Observation.		
				^h	^m	^s	^h	^m	^s
1861, Jan.	2	8	22 15.3	3	22	23.3	73	22	48.23
	3	8	26 39.2	3	22	22.22	73	24	25.32
	5	8	9 33.2	3	22	19.3	73	29	29.32
	8	7	53 8.8	3	22	33.22	73	36	5.23
	9	7	55 44.8	3	23	3.72	73	28	26.22
	11	7	43 2.3	3	24	15.26	73	22	15.58
	21	7	17 22.8	3	21	54.22	73	49	33.26
	24	6	54 7.5	3	20	7.42	74	41	40.26
	31	6	48 25.8	3	22	17.28	74	24	39.52

Melpomene (6).

Mean Solar Time of Observation.				R.A. from Observation.				N.P.D. from Observation.				
				^h	^m	^s	^h	^m	^s	[°]	[']	^{''}
1861, Jan.	2	14	30 42.9	9	21	30.26	81	34	32.26			
	3	14	26 11.5	9	20	55.21	81	29	35.69			
	5	14	17 3.5	9	19	32.27	81	18	53.23			
	7	14	7 50.2	9	18	17.17	81	7	28.94			
	8	14	3 10.8	9	17	33.59	81	1	26.13			
	9	13	58 30.1	9	16	48.64	80	55	12.67			
	21	13	0 46.0	9	6	13.77	79	27	30.10			
	24	12	21 16.1	8	58	9.85	78	19	38.07			
Feb.	2	12	1 27.8	8	54	4.51	77	44	25.14			
	11	11	17 16.1	8	45	14.56	76	25	24.15			
	15	10	57 59.1	8	41	40.61	75	51	37.24			
	25	10	11 17.8	8	34	17.13	74	34	2.61			
	28	9	57 47.5	8	32	34.32	74	13	12.50			

Fides (7).

Mean Solar Time of Observation.				R.A. from Observation.			N.P.D. from Observation.					
				h	m	s	h	m	s	°	'	"
1861,	Jan.	2		13	49	50.6	8	40	31.77	66	29	23.42
		3		13	45	6.9	8	39	43.89	66	25	59.54
		7		13	25	59.9	8	36	19.97	66	12	39.09
		8		13	21	9.3	8	35	25.23	66	9	16.08
		9		13	16	18.3	8	34	29.92	66	5	54.26
		21		12	17	6.8	8	22	27.36	65	29	42.79
		28		11	42	26.5	8	15	17.30	65	14	1.19
		29		11	37	31.2	8	14	17.72	65	12	17.67
	Feb.	1		11	17	58.9	8	10	28.42	65	6	1.48
		6		10	58	41.9	8	6	54.52	65	2	9.01
		11		10	35	7.5	8	2	59.02	64	59	47.75

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Fortuna (19).

Mean Solar Time of Observation.	R.A. from Observation.		N.P.D. from Observation.	
	h	m s	h m s	° ' "
1861, Jan. 9	7	25 10.9	2 42 24.80	75 33 44.65

Massilia (80).

Mean Solar Time of Observation.			R. A. from Observation.			N.P.D. from Observation.		
h m s			h m s			° ' "		
1861, Jan.	2	10 57 34.7	5 47 47.65	67 45 48.55				
	3	10 52 43.4	5 46 52.03	67 46 4.10				
	8	10 28 48.2	5 42 35.69	67 47 16.72				
	9	10 24 6.1	5 41 49.45	67 47 27.05				
	11	10 14 47.5	5 40 22.37	67 47 49.78				
	28	9 1 22.5	5 33 46.86	67 47 9.94				
	29	8 57 23.8	5 33 44.01	67 46 53.58				
	31	8 49 33.4	5 33 45.47	67 46 9.69				
Feb.	2	8 41 52.1	5 33 56.04	67 45 26.40				
	6	8 26 56.4	5 34 44.11	67 43 26.54				
	11	8 9 7.0	5 36 34.55	67 40 26.93				
	15	7 55 28.8	5 38 40.25	67 37 51.14				
	18	7 45 36.8	5 40 36.38	67 35 45.50				
	27	7 17 39.4	5 48 3.31	67 29 33.29				
	28	7 14 41.6	5 49 1.62	67 28 54.77				

Lutetia (81).

Mean Solar Time of Observation.	R.A. from Observation.			N.P.D. from Observation.					
	h	m	s	h	m	s	°	'	"
1861, Jan. 8	10	46	9.5	5	59	59.86	65	11	17.11
21	9	44	33.9	5	49	29.46	65	3	45.52

Proserpine (86).

Mean Solar Time of Observation.	R.A. from Observation.			N.P.D. from Observation.					
	h	m	s	h	m	s	°	'	"
1861, Jan. 29	12	38	45.0	9	15	41.60	68	9	14.21
Feb. 2	12	19	11.2	9	11	50.77	67	51	19.63
15	11	15	39.6	8	59	24.03	67	3	4.55

Amphitrite (88).

Mean Solar Time of Observation.				R.A. from Observation.			N.P.D. from Observation.					
				h	m	s	h	m	s	°	'	''
1861, Jan.	3			7	45	54.3	2	39	32.25	66	4	28.67
	8			7	28	1.9	2	41	19.76	66	7	50.55
	21			6	44	54.4	2	49	20.38	66	3	11.88

No Occultations of Stars by the Moon were observed.

Eclipses, Occultations, and Transits of Jupiter's Satellites.

Day of Ob- servation. 1861.	Satellite.	Phenomenon.	Mean Solar Time.			Observer.
			h	m	s	
Jan. 2	III	Ingress, bisection (a)	9	15	22.7	C.
2	I	Occ. reapp. last cont.	12	54	3.7	C.
2	III	Egress, last cont.	12	56	33.3	C.
3	I	Egress, first cont.	9	58	30.7	J. C.
3	I	„ bisection	10	2	30.1	J. C.
3	I	„ last cont.	10	6	29.4	J. C.
9	III	Shad. Ingr. bisection	9	50	7.9	J. C.
9	I	Ecl. disapp.	11	37	46.3	J. C.
9	II	Ingress, bisection	12	23	12.9	J. C.
9	III	Ingress, bisection	12	42	24.8	J. C.
9	III	Shad. Egr. bisection	13	28	2.3	J. C.
11	II	Occ. reapp. first app.	9	55	3.8	C.
11	II	„ last cont.	9	57	3.5	C.
23	II	Ingress, first cont. (b)	16	50	19.2	A. D.
23	II	„ bisection (b)	16	52	23.9	A. D.
23	II	„ last cont. (b)	16	54	23.6	A. D.
Feb. 2	I	Ingress, last cont. (c)	9	13	7.4	M. D.
2	I	Egress, first cont.	11	27	45.3	M. D.
2	I	„ last cont.	11	31	44.7	M. D.
6	IV	Ecl. disapp.	8	7	17.9	E.
6	IV	Occ. reapp. bisection	13	46	37.2	E.
6	IV	„ last cont.	13	51	6.5	E.
11	I	Egress, bisection	7	37	26.5	C.
11	I	„ last cont.	7	39	11.2	C.
18	I	Ingress, first cont.	7	3	45.1	A. D.
18	I	„ bisection	7	5	44.7	A. D.
18	I	„ last cont.	7	7	14.5	A. D.
18	I	Egress, bisection	9	24	7.1	A. D.
18	I	„ last cont.	9	26	6.7	A. D.
21	III	Ingress, first cont.	12	7	49.3	K.
21	III	„ bisection	12	10	20.9	K.
21	III	„ last cont.	12	15	20.1	K.
28	III	Ingress, first cont.	11	48	35.4	N.
28	III	„ bisection	11	52	4.8	N.
28	III	„ last cont.	11	54	39.4	N.
28	III	Shad. Ingr. last cont.	13	38	32.4	N.

(a), The images very tremulous. (b), The limbs of the planet badly defined, especially at the last contact. (c), Unsatisfactory.

The initials E., C., J. C., M. D., K., A. D., and N., are those of Messrs. Ellis, Criswick, Carpenter, Dolman, Kerschner, Davis, and Newcomb.

Discovery of Minor Planet (64).

A telegraphic despatch from Marseilles appeared in Le Verrier's *Bulletin* for the 6th of March, announcing this discovery, which, by a subsequent account, proves to be due to M. Tempel. The places given are

March 4	^h 14 ^m 40	R.A. 12 ^h 3 ^m 56	Decl. — 2° 5'
3	14 11	12 3 11	— 2 1

The discovery of the Minor Planet (66) and of the last-mentioned Planet (64) was announced from the Chair by the President.

A third discovery has since followed closely on those just referred to, the account of which is given from Le Verrier's *Bulletin* of March the 10th:—

Discovery of Minor Planet (65).

This planet was also discovered by M. Tempel at Marseilles, in the immediate neighbourhood of (64). The first place given in the despatch is:—

March 9	^h 11 ^m 24	R.A. 12 ^h 6 ^m 19.5	Decl. + 1° 1' 46"
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The following positions observed by M. Tempel of the Planets (66) and (64) may be added:—

Minor Planet (66).

	Marseilles M.T.	R.A.	Decl.
	^h ^m ^s	^h ^m ^s	° ' "
March 2	10 45 31	10 53 8.4	+ 6 20 9
3	8 55 3	10 52 10	+ 6 24 12
4	10 31 38	10 51 4	+ 6 28 43
6	9 47 33	10 49 3	+ 6 34 41
8	9 53 44	10 47 0	+ 6 41 19

Minor Planet (64).

	Marseilles M.T.	R.A.	Decl.
	^h ^m ^s	^h ^m ^s	° ' "
March 4	14 40	12 3 56	— 2 5 27
5	14 11 36	12 3 10.8	— 2 1 23
6	10 32 8	12 2 31.7	— 1 56 53
6	13 46 24	12 2 24.5	— 1 56 15
7	11 42 40	12 1 41	— 1 51 53
8	10 34 53	12 0 54	— 1 48 26

It is not stated, but is probable, that the above places are corrected for refraction, but not for parallax.

On a Method for determining Longitude without Clock.

By M. Radau.

In the *Géodésie d'Ethiopie*, par M. D'Abbadie, I have suggested a method for finding the latitude without needing a clock, by means of an altazimuth, and have explained the method of corresponding azimuths, which has been proposed by M. D'Abbadie, and may be used for ascertaining the meridian also without chronometer (see *Astr. Nach.*, No. 1298). But it would seem to be much less easy to find out the longitude in the case where a traveller is deprived of this latter instrument, since the clock is generally considered as being indispensable for such an observation. I, therefore, think it right to communicate a method I have conceived some time ago, which seems to me, when well employed, to answer that purpose in a satisfactory manner. I suppose, at first, the latitude of the place to be already known. It is then possible to obtain the longitude by means of alternate observations of the Moon and a Star, as well in altitude as in azimuth. The Star's altitudes may be used for calculating its azimuths and hour-angles: the former supply the orientation of the Moon's azimuths; the latter afford, with a sufficient degree of accuracy, the time of the mean of the lunar observations, which is wanted for computing a double ephemeris of the Moon's azimuths and altitudes, with two assumed longitudes, l and $l + 100^\circ$. Hence we may deduce, by interpolation, two systems of altitudes corresponding, in each case, to the observed azimuths of the Moon, and the comparison of these two systems leads to the determination of the true longitude. The correction Δl , which the assumed longitude l has to undergo when the zenith distance z , computed for a given azimuth, differs from observation by Δz seconds in arc, depends upon this formula:—

$$\frac{\Delta l}{\Delta z} = \frac{1 - \mu}{\nu} \cos q + \frac{\sec \delta}{15} \sin q,$$

where q is the parallactic angle, δ the moon's declination, ν her motion in declination per second, and μ that in right ascension (given in time is also the longitude). We shall have, of course, $\frac{1}{\nu} > 4$, $1 - \mu > 0.95$, and $\frac{\sec \delta}{15}$ between 0.07 and 0.08.

It is evident that for those observations the Moon must be near the equator, because, in that case, the quantity ν is considerable enough, and likewise, that it is necessary to observe near the prime vertical, where the angle q is at a maximum. For this latter reason the method is also better suited to tropical countries than to higher latitudes. Besides, it would be well to take the Moon in the east when her declination is increasing (ν pos., $\sin q$ neg.) and in the west when it is diminishing (ν neg., $\sin q$ pos.). I have had no opportunity

for making a trial of this method, and it would be very satisfactory for me to learn whether observers find it to be advantageous in practice.

Paris, January 1861.

Mr. Nasmyth, in a private letter to Mr. De La Rue, dated 5th Feb. 1861, states that he finds that the entire luminous surface of the sun is resolvable into the most complex superposition of elementary lense-shaped figures, arranged without any approach to symmetrical order in the details, but rather (if the term may be used) in a sort of regular random scattering; the letter was accompanied by a photograph from the original drawing, and an illustrative paper model.

In a letter, dated the 5th March, 1861, Mr. S. Gorton calls attention to the extremely dark appearance of the 3d and 4th Satellites of *Jupiter* in transit over the disk of the Planet, as seen by him and one or two other observers, the transit of the 3d Satellite on the 28th February, and that of the 4th Satellite on the 3d March; and he incloses a copy of his notes of the observations, as also of those of the transit on the 4th March of the 1st Satellite, which was almost invisible on account of its brightness. The dark appearance of the 4th Satellite on the transit of the 3d March is also noticed in a communication from Mr. T. W. Burr, whose account of the observation has, however, appeared in print elsewhere. The phenomenon, as regards both the 3d and 4th Satellites, has been frequently observed, see *Monthly Notices*, vol. xx. pp. 57 and 245, 246.

M. Goldschmidt, in a letter dated the 2d March, 1861, addressed to the Foreign Secretary, expresses his gratitude to the Royal Astronomical Society for the recompense and encouragement given to him by the award of the Medal.

There are contained in the *Comptes Rendus* (t. xlix., p. 673, t. l., p. 474, and t. li., p. 964) notices of a memoir "Sur les Cartes Géographiques," by M. A. Tissot. In the first part the author gives the law of deformation about each point, whatever the system of representation may be; in the second, he compares together those which have been employed or only proposed, for the construction of maps of the world; in the third part he resolves the question,—to find the best mode of

projection for any particular country. There exists an infinity of systems of representation, which do not modify the angles; but in the case of a country such as Russia, of an exceptional extent in all directions, even in selecting the system which reduces to a minimum the greatest variation of distance, the scale would undergo large variations in the extreme portions of the map, unless indeed the country represented be divided into regions having each of them its own map. The following are consequently the most important cases. 1°, a portion of the terrestrial surface of small extent in latitude, but of any extent whatever in longitude; 2°, one of small extent in longitude, but of any extent whatever in latitude; 3°, a country of moderate extent in latitude and longitude, as France, Spain, &c.

Let L be the latitude of any point, L_0 that of a central point, m the longitude of the first point from the second, r the radius of the parallel the latitude whereof is L , r_0 that of the parallel the latitude whereof is L_0 , s the arc of meridian comprised between these two parallels, x and y the rectangular co-ordinates on the map, of the point the latitude whereof is L and longitude m .

In the first case the best system of projection is given by the formulæ

$$(1) \quad x = S + \frac{1}{2} r m^2 \sin L, \quad y = r m \left(1 + \frac{1}{6} m^2 \cos 2L \right).$$

In the second case, putting

$$R_0 = r_0 \operatorname{cosec} L_0, \quad R = R_0 - S - \frac{1}{6} S^2, \quad \phi = m \sin L_0,$$

then the formulæ are

$$(2) \quad x = R_0 - R \cos \phi, \quad y = r \sin \phi.$$

In the third case if N_0 is the great normal of the meridian at the latitude L_0 (? the portion of the normal, intersected between the point on the surface and the polar axis), and if μ denote the variable quantity $m \cos L_0$, then the formulæ are

$$(3) \quad x = s + \frac{1}{2} N_0 \tan L_0 \mu^2 + \frac{1}{3} A s^3 - B s^2 \mu + C s \mu^2 + \frac{1}{3} B \mu^3,$$

$$y = r m + A s^2 \mu - B s \mu^2 + \frac{1}{3} C \mu^3,$$

where $L - L_0$ may be substituted in the place of s , except in the first term of the expression for x ; A, B, C , are constant coefficients, the third of which is connected with the first by the equation

$$2(A + C) \cos^2 L_0 = \cos 2L_0,$$

and A and B depend on the form of the contour of the country, and are obtained as follows; first tracing the contour by referring each of its points to two rectangular axes by means of the co-ordinates $L-L_0, \mu$, it is easy by a few graphical trials to determine in magnitude and position the enveloping ellipse such that the diameter inclined 45° to the two axes is the least possible: Let $2d$ be the length of this minimum diameter, $2a$ that of the corresponding major axis, α the inclination of such major axis to the axis of the co-ordinates μ ; then

$$(4) \quad A = \frac{1}{2} \left(\cos^2 \alpha - \frac{d^2}{2a^2} \cos 2\alpha \right), \quad B = \frac{1}{4} \left(1 - \frac{d^2}{a^2} \right) \sin 2\alpha,$$

the centre of the ellipse will give the central point of the map, and consequently the latitude L_0 , an approximate value whereof will have been sufficient for the purpose of this preliminary construction.

For certain exceptional contours the mode of projection must be somewhat modified. Lastly, there may be introduced on the right-hand sides of the equations (1), (2), and (3), a constant factor which it is easy to determine for each country in particular, and of which the effect is to diminish by one-half the greatest alteration in length, rendering this positive in certain regions and negative in others.

Applied to France, the foregoing researches give

$$(5) \quad A = 0.306, \quad B = 0, \quad C = -0.368, \quad L_0 = 41^\circ 40'$$

and the central meridian is that of Paris. Applied to Spain, the central meridian is that of Madrid, and the central parallel that of 40° ; the formulæ are

$$x = s + 0.42013 \mu^2 + 0.111 s^2 - 0.185 s^2 \mu,$$

$$y = r m + 0.333 s^2 \mu - 0.062 \mu^2.$$

A table is given showing, for six different countries, the greatest alteration of angle and the greatest alteration of distance produced by the mode of projection adopted in the construction of the map of France by the Dépôt de la Guerre, and by one of those proposed in the Memoir.

For sale, an Equatoreal Telescope, 5 feet focus, 4.15 inches aperture; object-glass by Messrs. Cooke and Sons, of York; nine astronomical and three terrestrial eye-pieces; diagonal solar eye-piece and dark glasses; position and distance micrometer; iron mortar stand; declination circle, 14 inches diameter; right ascension circle, 6 inches diameter; clamps, hooks, joints, and handles. Apply to the Assistant Secretary.

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MONTHLY NOTICES
OF THE
ROYAL ASTRONOMICAL SOCIETY.

VOL. XXI

April 10, 1861.

No. 6.

Dr. LEE, President, in the Chair.

- Major Strange, H.M. Indian Army ;
 - Dr. Nottingham, Liverpool ;
 - H. J. S. Smith, Esq., Balliol College, Oxford ; and
 - Lieut. Cuspendale, H.M.I.N.,
- were balloted for and duly elected Fellows of the Society.

The twenty-ninth volume of the *Memoirs* is ready for delivery. It contains the longer papers read at the Meetings of the Society, and also the twentieth volume of the *Monthly Notices*, reprinted in a quarto form, thus giving a complete account of the proceedings of the Society during the year. The price is 5s. to Fellows, and 15s. to the public.

The Astronomische Nachrichten.

The publication of the fifty-fifth volume has recently commenced. The price per volume is 15s., payable in advance. Two volumes are generally published in the course of the year. Fellows of the Society desiring to become subscribers may send a notification to that effect to Mr. Williams, the Assistant Secretary of the Society, who will receive the subscription.

On the Morning Illumination of two disrupted Lunar Craters, unnoticed by Webb and unnamed by Beer and Mädler. By W. R. Birt, Esq.

On a few former occasions I have presented to the attention of the Society notices of the morning and evening illuminations of lunar craters, possessing features that withdraw them from the general type of the cup-shaped cavities abounding on the Moon's surface, inasmuch as their rings are incomplete and they are mostly found in localities of a peculiar character, viz., on the borders of the *Maria*, the disrupted portions of the rings being in the cases quoted towards the *Maria*, see *Monthly Notices*, vol. xx. p. 69, *Fracastorius*; p. 211, *Hippalus*; and p. 280, *Schröter's Newton*.

On the evening of March 22, 1861, between 6^h 50^m and 9^h 15^m G.M.T., I had an opportunity of observing the southern part of the *Mare Humorum*, then under an early morning illumination; the eastern portion, with the mountains composing it, being observed beyond the terminator as splendid lucid points. *Gassendi* was a most magnificent object, the atmosphere being in a fine state for definition, many minute features were brought out not ordinarily discernible.

The two craters marked on Beer and Mädler's map, and also on Webb's index map, 229 and 230, as abutting on the southern part of the *Mare Humorum*, are *Vitello* and *Doppel-mayer*. The first, *Vitello*, is a perfectly ringed crater, with a central mountain of somewhat considerable dimensions, it is seen under this illumination to rise magnificently from the floor of the crater, the shadow of the western wall partially surrounding its base.

The second, *Doppelmayer*, is an imperfectly ringed crater, the imperfection indicating a destruction of the mountains that formed this part of the wall, being, as in the cases already quoted, *towards the Mare*. This crater has a central mountain, casting at this epoch a long shadow towards the eastern part of the ring.

Between these craters, and filling the entire space, are the remains of a large crater, having to the south-east a smaller one, the level of the larger partially destroyed crater appearing to be slightly depressed below the level of the adjoining portion of the *Mare*.

On the western margin this larger crater does not appear under this illumination to possess a wall proper to itself, but at an epoch about 24 hours later, as seen on March 23^d 8^h 20^m, the illumination then brings out very distinctly its western wall, just touching the wall of *Vitello* and extending each way, on the north to the abrupt termination of the broken wall, where it meets the general level of the *Mare*, and on the south to the abrupt termination of the broken wall of the smaller crater to the south-east. The interior shadows of the western

walls of both craters are well marked at the later epoch, and the original outline of the larger crater traced by means of a few scattered peaks, or rather blocks, to its junction with the wall of *Doppelmayer*, where that also is broken by the disruptive force which appears to have acted simultaneously on the three craters.* Under this illumination *Doppelmayer* offers a fine example of the action of this overspreading force, the north-west part *towards the Mare*, within a portion of the standing walls, as far as the central mountain, presenting a slightly greenish grey appearance, while the other half of the crater remains in its original, or at least former state, the contrast of the two being very decided. The illumination at about 12.25 days of the Moon's age is much more suitable for bringing out the features of the partial destruction of the walls of the three craters than the earlier illumination at 11.25 days, it is then that the eastern wall of *Vitello* with its sharp curvature casting a deep and extensive shadow on the western portion of the floor of the large disrupted crater suggests the idea that *Vitello* is a more recent crater than either *Doppelmayer* or the large unnamed crater.

A little to the south-east of this large disrupted crater I observed a smaller one, the south-east portion of its ring being *exterior* to what may be considered the south-east boundary of the larger crater, which evidently appears to have been torn away. A ridge extending between the walls of the smaller crater and *Doppelmayer* gives a certain feature of angularity to the rampart composed of the walls of the two craters and the included ridge; and this is so marked as (in addition to the position of the smaller crater, indicating its more recent formation, being partly on and partly off the area of the larger crater), also to confirm the idea of the different epochs of the origin of the two.

While the wall of the smaller crater is complete on the south and south-east, its northern portion has been partially destroyed; in this respect it agrees very closely with the features presented by the larger crater, the whole of the walls of which, except those mentioned above, having been destroyed; a few peaks remain on the northern ring of the smaller crater, which thus has some affinity with the crater *Fracastorius*. The south-west portion of the ring casts a deep shadow on the floor, which appears to be of a rather lower level than the crater on which it partly stands.

It will be seen, on referring to the *Monthly Notices*, vol. xx. p. 211, that *Hippalus* is situated on the north-west border of an arm of the *Mare Humorum*, and that the disrupted portion

* At the *earliest* epoch of illumination of the large disrupted crater, viz., about 10.6 days of the moon's age, and about 2.6 days after the epoch of greatest south-east libration, I have seen the circular outline of its ring nearly complete, the blocks mentioned in the text catching the first rays of the rising sun.

faces this arm. On viewing these features that are thus common to the disrupted craters situated on the borders of this *Mare*, one almost feels disposed to venture a conjecture that here we have the means of approximating to the successive ages of some of the crateriform productions on the lunar surface. "Every thing which tends to throw light on the manner in which the inequalities on the Moon's surface have originated," says Arago, "is eminently deserving of attention." Taking *Doppelmayr*, south-east, and *Hippalus*, north-west, we have evidence of the disruptive force existing between them, in fact extending south-eastward, south-westward, and north-westward. Has this force any connexion with the overspreading of the *Mare* with its plain-like covering? Assuming for a moment that such is the case, we do not know that it is so, we have the two craters named with the two unnamed more ancient than the overspreading of the *Mare* itself—the small unnamed crater being more recent than the one near which it stands and which it partially covers, and probably more recent than the other three. The age of *Vitello*—with its still perfect walls closely adjoining as they do the western flank of the large unnamed crater—more recent than the period of the overspreading of the *Mare*; and the magnificent *Gassendi*, also more recent than this period, probably marking an epoch, the most recent of the violent outbursts which produced such magnificent craters as the one just named, *Copernicus*, *Tycho*, *Plato*, and several others which appear to be most perfect, *Copernicus* having suffered considerably from degrading agencies.

On an Appearance on the Surface of Jupiter, which passed rapidly over the Disk of the Planet. By W. R. Birt, Esq.

On the 22d of March, 1861, at about 7^h 20^m G.M.T., I noticed near the eastern limb of *Jupiter* a difference in the breadth of the northern belt, a small portion near the limb was about half the breadth of the remainder, which extended to near the western limb, the termination of the half-breadth of the broadest was rugged and irregular; about 40 minutes later, viz. at 8^h, this ragged portion occupied the centre of the disk with a somewhat dark spot near its termination. At 9^h 15^m this portion had arrived within a tenth of the longest diameter of the disk from the western limb. When next I noticed *Jupiter* it was gone, and he had two well-defined narrow belts; at 11^h I observed a fine line-like belt just north of the narrow belt.

Was this an instance of a rapid propagation of cloud in the atmosphere of the planet?

Observations of Saturn. By Warren De La Rue, Esq.

While observing *Saturn* during the last few weeks my attention has been attracted by the very irregular outline of the shadow crossing the planet's northern hemisphere just above the inner dark ring. I noticed this very distinctly on the night of the 7th instant, when my 13-inch Newtonian Equatorial bore a power of 700 perfectly well. On that and other occasions I scrutinised the planet with a very beautiful achromatic by Dallmeyer (the late Mr. Ross's son-in-law) of $4\frac{1}{8}$ inches aperture, and I noticed the same appearance, so that



astronomers possessing instruments of moderate size may observe the phenomenon provided they define perfectly. It is right to mention that the achromatic I refer to shows the 5th and 6th stars in the trapezium of *Orion*, and that on a clear night I even made out *Enceladus*, having first observed it, however, with the 13-inch reflector.

Cranford, April 11, 1861.

Photographs of the Total Eclipse.

By Warren De La Rue, Esq.

I am desirous of an opportunity of making known to Astronomers that some further delay will take place before copies of the two totality pictures can be printed off for circulation. In order to show the details of the protuberances it is necessary to enlarge the copies to about 9 inches in diameter, and from these to make a sufficient number of negatives to print the paper copies it is proposed to publish.

A few perfect positives were obtained soon after the return of the Himalaya Expedition from Spain, but they have been used up in making the engraved plates in the manner already made known to the Society. Since the size of the intended volume of Reports has been settled by the Astronomer Royal, several attempts have been made to procure the positive transparent enlarged copies, which will serve to make the negatives to print from, but hitherto without success, in consequence of the want of favourable weather. Up to yesterday all attempts to multiply copies have failed, for nothing short of an unobscured brilliant Sun will penetrate the dense original negatives so as to show the details of the protuberances; after spending 21 days in fruitless attempts I have come to the conclusion that it will be better to defer for a few weeks longer any further trials. An exposure of 40 to 45 seconds suffices in brilliant sunlight to produce a perfect picture, but an exposure of 15 minutes fails to produce a picture worthy of circulation when the Sun is obscured by the mists which have been prevalent.

Crawford, April 11, 1861.

On a Micrometric Diaphragm. By L. H. Casella.

The impulse given of late to the study of solar physics by the accurate series of observations on the Solar Spots by Mr. Carrington, Dr. Wolfe, Schwabe, and others, is greatly calculated to enlist the energies of amateurs, and many a series of diagrams of the Solar Disk might be constructed, were a simple and easy method of obtaining the position of those spots readily attainable.

About two years since I constructed for Mr. Birt a micrometric diaphragm, which appears so suitable for obtaining approximate positions of the spots as to induce me to submit it to the attention of the Society, especially as I consider it will enable an observer, from a series of observations only, to lay down diagrams of the spots from day to day, which may be compared at leisure, and from which several questions may be approximately answered by many in whose hands the employment of more delicate instruments or methods with the calculations attendant on them would in a great measure prevent.

The diaphragm is of glass, fitted to the focus of the eyepiece, and engraved with equidistant parallel lines dividing the field into about thirty-five divisions, each line terminating a little beyond the transverse diameter of the field, except every fifth line, which extends quite across the field.

The value of each division can easily be ascertained in the usual way.

In observing the position of a spot, the upper or lower limb of the Sun is made to run along the lowest or highest line that stretches across the field; when this is nicely adjusted the spot is seen to traverse the field either on a line or somewhere between two, the proper adjustment being known by the spot keeping on a given line or being equally distant from the lines above and below it throughout its transit: it is then easy to see the number of divisions, and by estimating the parts of a division by which the spot is distant from the limb, tenths can be readily estimated and the approximate diameters of spots easily determined.

When the positions of all the spots visible are determined from the upper or lower limbs, the diaphragm is shifted a quarter of a revolution by simply turning the eye-piece in the tube, and each spot in succession is made to run along the extremities of the shorter lines. As the spots transit each line, so the preceding and following limbs also transit each line, and the remaining co-ordinate is determined by the number of divisions and parts by which the spot follows the preceding, or precedes the following limb.

Not only is the diaphragm suitable for obtaining these positions approximately to about 6", but it is also useful for readily laying down groups, the observer being prepared with paper ruled in squares on a large scale, when the co-ordinates of the principal members of the group are obtained as above. The minor spots may be inserted in their proper places in the manner of sketching; a little practice will soon enable an observer to lay down all the features of a group within the limits above indicated.

*Extract of a Letter from Dr. Winnecke to the Rev. R. Main,
dated 1861, March 26.*

"In No. 3 (of the *Monthly Notices*) Mr. Carrington brings forward the question concerning the figure of the sun—would it not be desirable to remind the Astronomical Society, on this opportunity of the measures made by Schlüter and Wichmann with the Königsberg heliometer, which, although they have fallen into oblivion, seem to determine the question for the present position of the science of observation? Schlüter observed the sun on five days in such a way as to make one measured diameter pass through the pole, while the other was at right angles to it. For this purpose he prepared an eph-

meris computed for the position of the sun's equator at that time. The following are the values obtained:

	Angle of Position of Pole.	Polar Diameter.	Equatoreal Diameter.
1842, Oct. 22	334 17'	31' 60" 30	31' 60" 09
1843, Feb. 28	21 36	59' 82	59' 41
„ March 17	24 56	59' 59	59' 75
„ March 21	25 27	59' 96	60' 06
„ June 4	14 9	59' 96	60' 33

Therefore the equatoreal diameters are greater by,

$$\begin{aligned}
 & -0' 21 \\
 & -0' 41 \\
 & +0' 16 \\
 & +0' 10 \\
 & +0' 37
 \end{aligned}$$

from whence in the mean there is perfect equality between the equatoreal and polar diameters.

“Nearly the same result is arrived at from measures made at the same place (*Königsberg Observations*, Part 30), in which diameters differing by angles of position amounting to 30° were employed.

“The diameter given above does not differ materially from that commonly received, as deduced from meridian observations. For the reduction of a series of meridian observations there has been for security employed that diameter of the Sun, deduced from the observations themselves, which corresponds to the instrument and the observer. But, when the question is to employ the true value of the diameter, there is no doubt that that which is derived from the observations made with the *Königsberg* heliometer deserves the preference. For no other instrument is the entire freedom from irradiation so evidently proved as for the *Königsberg* heliometer. The inequalities of the screw, and the value of one of its revolutions, have been investigated in an incomparable manner.

“The only thing which could have been wished for more in the preceding measures consists in the want of a satisfactory explanation of the external circumstances under which these observations were made. According to Schlüter's account it would appear as if he always observed with a sky densely covered, so that an anomalous heating of the object-glass and of the screws (the latter of which in particular were protected by white paper placed before them) is not to be feared. In Wichmann's observations this has not been always the case, so that Schlüter's results without doubt deserve the preference.

"Besides this, the intimation that possibly the thermometer-coefficient for the value of a revolution of a screw has not been taken into account with sufficient accuracy, has plainly a relation only to the absolute value of the diameter, without in the least affecting the conclusions respecting the figure of the Sun."

Observations of the Solar Eclipse of the 11th Jan., 1861, at the Sydney Observatory. By W. R. Scott, Esq., Astronomer for N. S. Wales.

In a letter dated February 19th, 1861, addressed to the Secretary, Mr. Scott writes:—

"I send herewith the results of my observations of the solar eclipse of January 11th.

"The eclipse was observed with the portable equatoreal telescope, $3\frac{1}{2}$ inches aperture. I obtained measurements of some chords, but cannot attach any value to them, owing to great instability of the mounting.

"The most accurate observation was the time of first contact of the Moon's limb with the first of two very black well-defined spots in the midst of a group of less defined spots.

"I regret that I was unable to leave the Observatory so as to visit a part of the colony where the eclipse was annular; neither have I received reports of any observations of the annular eclipse.

"The temperature observations were made with a black-bulb thermometer in an exhausted glass tube.

"I give the results from 1^h P.M., having reason to believe that those made before that time were not trustworthy.

"I am happy to state that I have reason to hope shortly to be enabled to produce some better work than the defective character of my instrumental means has hitherto allowed; as an equatoreal telescope by Mertz, with a 9-inch object-glass, is on its way from England.

"Being somewhat of a novice in practical astronomy, and isolated from the rest of the astronomical world, I shall feel grateful for any suggestions from your Society as to the best mode of co-operating (when my new instrument arrives) with the astronomers of Europe and America."

The observations referred to in the letter are,—

	Syd. M.T.
	h m s
Commencement of Eclipse, Jan. 11	0 38 14
Contact with spot	0 53 20
End of Eclipse	3 23 15

Observations with black-bulb thermometer,

h	m	ϕ	h	m	ϕ
1	0	125°6	2	25	96°0
1	15	117°5	2	30	97°6
1	20	113°8	2	35	98°4
1	25	112°0	2	40	100°0
1	30	110°5	2	45	102°0
1	35	107°0	2	50	104°0
1	40	104°8	2	55	106°7
1	45	103°6	3	0	109°7
1	50	100°3	3	5	112°6
1	55	98°8	3	10	115°5
2	0	97°7	3	15	117°3
2	5	96°6	3	20	119°0
2	10	95°3	3	25	121°1
2	15	95°0	3	30	121°2
2	20	94°8			

The sky was perfectly clear throughout.

Note on one of the Comites of β Geminorum.

By the Rev. T. W. Webb.

On reference to the Bedford Catalogue, it will be found that the third attendant of β *Geminorum* was described by Admiral Smyth, in 1832, as of equal brightness with the second, C of his nomenclature, which he rates of $11\frac{1}{2}$ magnitude. It now appears, with my $5\frac{1}{2}$ -inch object-glass, about as much inferior to B, $12\frac{1}{2}$ of the Admiral's scale, as B is below C; and as Sir James South's Equatoreal of 5 inches had shown but two companions some years before the date of the Bedford Catalogue, there is, perhaps, ground to suspect a variation in its light.

Hardwick Parsonage, April 22, 1861.

Results of the Observations of Small Planets made with the Transit-circle; Occultations of Stars by the Moon; and Eclipses, Occultations, and Transits of Jupiter's Satellites; observed at the Royal Observatory, Greenwich, during the month of March 1861.

(Communicated by the Astronomer Royal.)

Massilia (20).

Mean Solar Time of Observation.	R. A. from Observation.	N.P.D. from Observation.
h m s	h m s	o ' "
1861, March 4 7 3 5.9	5 53 10.15	67 26 37.61

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Hebe (8).

Mean Solar Time of Observation.			R.A. from Observation.			N.P.D. from Observation.		
		^h ^m ^s		^h ^m ^s		[°] ['] ["]		
1861, March	4	12 24 5'5	11	15 2'54		74 24 53'51		
	6	12 14 28'6	11	13 17'20		74 5 37'00		
	9	12 0 3'6	11	10 39'41		73 37 58'80		
	11	11 50 27'9	11	8 55'24		73 20 12'72		
	13	11 40 53'3	11	7 12'26		73 3 5'89		
	16	11 26 34'5	11	4 40'69		72 38 49'60		
	20	11 7 37'7	11	1 27'06		72 9 10'61		
	21	11 2 55'8	11	0 40'92		72 2 20'34		
	22	10 58 14'1	10	59 55'00		71 55 39'41		
	28	10 30 25'2	10	55 40'86		71 20 8'45		

Parthenope (11).

Mean Solar Time of Observation.			R.A. from Observation.			N.P.D. from Observation.		
		^h ^m ^s		^h ^m ^s		[°] ['] ["]		
1861, March	4	12 47 59'4	11	39 0'35		82 8 19'67		
	6	12 38 24'6	11	37 17'06		81 53 59'27		
	8	12 28 48'4	11	35 32'45		81 39 37'24		
	9	12 23 59'0	11	34 38'78		81 32 23'87		
	11	12 15 21'4	11	32 52'91		81 18 16'04		
	13	12 4 43'4	11	31 6'23		81 4 17'68		
	16	11 50 16'0	11	28 26'07		80 43 55'15		
	20	11 31 2'7	11	24 55'90		80 18 7'69		
	21	11 26 15'9	11	24 4'79		80 11 58'35		

Melpomene (14).

Mean Solar Time of Observation.			R.A. from Observation.			N.P.D. from Observation.		
		^h ^m ^s		^h ^m ^s		[°] ['] ["]		
1861, March	4	9 40 10'4	8	30 40'50		73 47 24'79		
	6	9 31 32'4	8	29 54'18		73 35 16'72		
	8	9 23 1'6	8	29 15'08		73 23 46'91		
	11	9 10 28'5	8	28 29'56		73 7 40'80		
	13	9 2 15'7	8	28 8'51		72 57 42'31		
	21	8 30 34'9	8	27 54'96		72 23 50'57		
	22	8 26 45'0.	8	28 1'02		72 20 21'47		
	23	8 22 57'0	8	28 8'89		72 16 55'16		
	28	8 4 20'4	8	29 11'99		72 2 1'79		

Fides (67).

Mean Solar Time of Observation.			R.A. from Observation.			N.P.D. from Observation.		
		^h ^m ^s		^h ^m ^s		[°] ['] ["]		
1861, March	8	8 48 23'5	7	54 31'35		65 28 40'92		
	16	8 18 23'0	7	55 58'33		65 49 21'15		

Ausonia (60).

Mean Solar Time of Observation.			R.A. from Observation.		N.P.D. from Observation.		
	h	m	s	h	m	s	
1861, March 15	11	5	55.2	10	40	1.43	82 55 2.74
16	11	1	2.9	10	39	4.94	82 52 2.07

Angelina (61).

Mean Solar Time of Observation.	R.A. from Observation.			N.P.D. from Observation.					
	h	m	s	h	m	s	°	'	"
1861, March 15	11	51	58.3	11	49	51.45	90	43	18.14
22	11	47	11.6	11	49	0.53	90	38	11.56

The observations in N. P. D. of *Ausonia* and *Angelina* have been corrected for Refraction only; those of all the others for both Refraction and Parallax.

Occultations of Stars by the Moon.

Day of Obs.	Phenomenon.	Moon's Limb.	Mean Solar Time.	Observer.
			h m s	
1861, Mar. 19	5 Geminorum disapp.	Dark	8 53 55.4	D.
21	B. A. C. 2683 disapp.	Dark	9 43 39.3	C.
21	B. A. C. 2683 reapp. (a)	Bright	10 20 7.4	C.

(a), The star was slightly separated from the limb when first seen.

The initials D. and C. are those of Mr. Dunkin and Mr. Criswick.

Eclipses, Occultations, and Transits of Jupiter's Satellites.

Day of Observation. 1861.	Satellite.	Phenomenon.	Mean Solar Time.	Observer.
			h m s	
Mar. 4	III	Ecl. reapp.	7 23 17.0	A. D.
4	I	Ingress, Bisection	10 35 59.6	J. C.
4	I	„ last cont.	10 38 29.2	J. C.
4	I	Egress, last cont.	12 57 32.3	A. D.
6	I	„ bisection	7 20 26.8	K.
6	I	„ last cont.	7 22 26.5	K.
11	III	Ecl. reapp.	11 21 15.1	E.
11	I	Ingress, bisection	12 20 25.4	E.
11	IV	Occ. disapp. bis.	13 31 43.8	E.
16	II	Ecl. reapp.	7 57 59.9	E.
21	I	Ecl. reapp.	8 52 17.7	C.
21	II	Ingress, bis. (a)	10 55 49.4	C.
28	IV	Occ. reapp. bis.	9 38 1.6	E.

(a) The planet extremely tremulous and blurred; the observation very unsatisfactory.

The initials E., C., J. C., K. and A. D. are those of Messrs. Ellis, Criswick, Carpenter, Kerschner, and Davis.

Note.—In the *Monthly Notices* for June, 1860, vol. xx., No. 8, p. 328, the places of two objects are given for *Thetis*, with the remark that their proximity made it doubtful which was the planet, though the second was thought to have the greater probability, on account of its magnitude. That this second, marked (*b*) R.A. $14^h 3^m 52^s.32$, N.P.D. $92^\circ 40' 11''.98$, really was *Thetis*, was proved by an observation with the transit-circle on 1861, April 11, when an object was seen answering to (*a*), but nothing in the place of (*b*).

Occultations of Stars by the Moon, observed at Forest Lodge, Maresfield, Sussex. By Capt. W. Noble.

Sunday, February 17, 1861.

Occultation of 23 *Tauri* by the Moon.

The star disappeared instantaneously at the Moon's dark limb
at $7^h 51^m 7^s.7$ L.S.T. = $9^h 52^m 59^s.75$ L.M.T.

Owing to the dense haze, the reappearance could not be observed.

Power 135 (with positive eye-piece) adjusted on the star.

Thursday, March 21, 1861.

Occultation of B.A.C. 2683 by the Moon.

	h	m	s	h	m	s
The star disappeared instantaneously at the Moon's dark limb at	9	43	11.4	L.S.T. =	9	45
and reappeared at	10	17	46.6	L.S.T. =	10	20
					8	58
					L.M.T.	

It was very faint at its reappearance, owing to the overpowering brightness of the Moon, and the time of its apparition may therefore be $+0^s.5$ in error.

Power 115 adjusted on the star.

My 4.2 inches Equatoreal was employed in each observation.

In a letter to Mr. Carrington, dated 11th April, 1861, Capt. Noble writes :—

“Inasmuch as I think that every abnormal circumstance, however trivial, should be placed upon record, I may tell you that while examining the Sun on Thursday, March 28th, at 2^h 30^m G.M.T., with a power of 74, I found that the carefully determined solar focal length of the object-glass, with the eye-piece employed, was *shortened* exactly 0·11 inch ! There was a good deal of haze about at the time. The barometer stood at 29ⁱⁿ·340, and the thermometers outside of the observatory at 55°. I can find no notice in any work to which I have access of this curious phenomenon of a considerable alteration in the focal length of a telescope, nor can I presume to theorise upon the matter. The quantity by which the focus was changed was too great to have had its origin in any unusual condition of my own eye ; besides which, when the sky cleared, the focus lengthened again to its standard distance. It seems to me that in such alteration we have an explanation of a fertile source of many discrepancies which occur in accounts of the same phenomenon as viewed by different observers, and perhaps even a better one of the inconsistency of observations made by the same individual.”

Observations and Elements of Comet III. 1860. By Dr. C. G. Moesta, Director of the National Observatory of Santiago de Chile.

I enclose some observations of Comet III., 1860, seen by me for the first time on the evening of July 10th, and which has been observed here on several nights until the 13th of September. Most of the comparison-stars are probably not to be found in the Catalogues of southern stars, and I intend to determine their positions by the Meridian-Circle as soon as the season will permit it. On the 13th of August the Comet was compared with γ and α *Centauri*, and on the 12th of September with Taylor 8002. Adopting the positions of these stars, such as they are given in the B.A.C. and Taylor's Catalogue, I obtained the following positions of the Comet :

	G.M.T.	App. R.A.	App. Decl.
	h m s	h m s	° ' "
August 13	14 43 8·7	13 47 26·92	-40 19 32·8
September 12	12 48 30·8	15 2 50·64	-47 24 1·6

With approximate elements I formed a normal place of the three observations made at Bonn and Altona (*Ast. Nach.* No. 1266), and after having applied the corrections for parallax and aberration, and reducing all observations to the mean equator for 1860.0, I collected the following places of the Comet:

G.M.T.		R.A.	Decl.
		^h ^m ^s	[°] ['] ["]
Altona and Bonn, June 23	50000	6 45 40.12	+42 18 45.6
Washington, July 14	56297	10 59 11.56	- 1 4 7.5
Santiago, Aug. 13	60642	13 47 24.98	-40 19 9.7
Santiago, Sept. 12	52198	15 2 48.07	-47 23 38.5

The observation of July 14th (*Ast. Nach.* No. 1273) is based upon the following position of Weisse X, 1099, as determined by me with the Meridian Circle:

For 1860.0.

Mean R.A. = 11^h 1^m 7^s.76, Decl. = -1° 8' 44".4

By variation of the distances of the Comet from the Sun I found the adjoined parabolic elements, which represent the first and last of the given places, leaving the following errors in the middle places,—

	O — C. Δ long.	O — C. Δ lat.
Washington, July 14	-7.1	- 2.5
Santiago, August 14	+6.7	-12.4

Elements.

T = 1860, June 16.05950 G.M.T.

$\Omega = 84^{\circ} 40' 3.8''$
 $\pi = 161^{\circ} 31' 59.3''$ } Mean Eq., 1860.0.

$i = 79^{\circ} 18' 33.76''$

Log $q = 9.4667171$.

Motion direct.

It appears, therefore, that a parabola will represent very well the observations during three months, and that the excentricity of the orbit must be very nearly equal to unity.

Santiago de Chile, Feb. 17, 1861.

Ephemeris of the Variable Stars for 1861. By Norman Robert Pogson, Esq., Director of the Madras Observatory.

In this ephemeris the initials in the sixth column represent the following names:—
A., Argelander; B., Baxendell; K., Krüger; P., Pogson; S., Schönfeld; W., Winnecke.

Star.	Probable Mag.	Mean Place, 1860.				Times of Maxima.	Authority.	
		R.A.	N.P.D.					
		^h °	^m '	^s "	[°] '			
T Piscium	9.5	0 24 46	76	14		Feb. 17, July 10, Nov. 30	...	S.
α Cassiopeie	2.0	0 32 35	34	14		Feb. 18, May 8, July 26, Oct. 13, Dec. 31		A.
R Arietis	8.0	2 8 10	65	36		Jan. 23, July 28	...	W. & B.
α Ceti	2.0	2 12 17	93	37		August 6	...	A.
R Tauri	8.0	4 20 38	80	9		June 15	...	W.
S Tauri	10.0	4 21 32	80	22		February 27	...	W.
R Orionis	9.0	4 51 22	82	5		June 6	...	—
α Orionis	1.0	5 47 36	82	37		June 28	...	—
R Geminorum	7.3	6 58 56	67	5		January 19	...	P.
R Can. Min.	8.0	7 1 0	79	46		April? Uncertain	...	—
S Can. Min.	7.5	7 25 7	81	23		July 28	...	W.
S Geminorum	9.2	7 34 38	66	13		Jan. 5, Oct. 26	...	P.
T Geminorum	8.9	7 40 54	65	55		July 28	...	—
U Geminorum	9.1	7 46 48	67	38		April 5, July 11, Oct. 16	...	—
R Cancrī	6.0	8 8 51	77	51		Between Feb. 15 and April 23		B. & A.
U Cancrī	9.0	8 27 45	70	37		August 31	...	W.
S Hydræ	8.5	8 46 16	86	24		May 10	...	—
T Cancrī	12.0	8 48 40	69	37		At minimum, Sept. 28	...	—
T Hydræ	6.5	8 48 51	98	37		May 6	...	—
R Leonis	5.0	9 40 2	77	55		{ Jan. 2, Nov. 22. At minimum, } { July 9	...	P.
R Urs. Maj.	7.0	10 34 41	20	29		July 1. At minimum, March 10		P.
T Leonis	9.0	11 3 36	83	47		Jan. 5, July 24	...	W.
R Comæ	8.0	11 57 4	70	26		October 8	...	—
R Virginis	6.5	12 31 24	82	14		March 16, Aug. 9	...	A.
S Urs. Maj.	7.5	12 37 48	28	8		{ Jan. 14, Aug. 28. At minimum, } { May 21	...	P.
U Virginis	7.5	12 44 0	83	41		May 30, Dec. 28	...	W.
V Virginis	7.0	13 20 36	92	28		July	...	P.
R Hydræ	4.0	13 22 4	112	33		Nov. 15. At minimum, Oct. 30		W.
S Virginis	6.0	13 25 42	96	28		May 8	...	P.
R Boëtis	8.0	14 31 1	62	39		July 6	...	W.

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Star.	Probable Mag.	Mean Place, 1860.				Times of Maxima.	Authority.
		R.A. h m s	Dec. ° ' "	N.P.D. °			
S Serpentis	8.0	15 15 7	75 11	March 11	...	...	A.
R Coronæ	6.2	15 42 49	61 25	Between July 12 and Sept. 30			A. & B.
R Serpentis	6.5	15 44 15	74 26	August 23	...	...	A.
R Libræ	9.0	15 45 40	105 49	Probably not during 1861			P.
R Herculis	8.5	15 59 56	71 15	Feb. 12, Dec. 19	...	...	W. & B.
R Scorpii	9.0	16 9 19	112 35	Not during 1861	...	...	P.
S Scorpii	9.5	16 9 20	112 33	April 19	...	...	—
S Ophiuchi	9.3	16 26 12	106 52	April 27, Dec. 16	...	...	—
S Herculis	7.5	16 45 32	74 49	Jan. 13, Nov. 14	...	...	B.
R Ophiuchi	7.6	16 59 44	105 54	August 28	...	...	P.
α Herculis	3.0	17 8 16	75 27	{ Feb. 5, April 13, June 18, Aug. 24, } Oct. 29			A.
T Herculis	7.9	18 3 48	59 0	April 30, Oct. 7	...	...	K.
R Scuti	5.0	18 40 1	95 50	{ Jan. 14, March 27, June 6, Aug. 17, } Oct. 28			A.
13 Lyræ	4.3	18 51 4	46 14	{ Jan. 25, March 13, April 28, June 14, } July 30, Sept. 15, Oct. 31, Dec. 16			B.
R Aquilæ	6.5	18 59 38	81 59	May 26	...	...	A.
R Sagittarii	8.2	19 8 28	109 33	February?	Irregular	...	P.
R Cygni	8.0	19 33 4	40 7	Sept. 23.	At minimum, April 21	...	—
α Cygni	5.0	19 45 11	57 27	April 20	...	...	A.
R Capricorni	9.5	20 3 28	104 41	September 30	...	...	W.
U Capricorni	10.5	20 40 22	105 18	February	...	...	P.
R Vulpeculæ	8.0	20 58 10	66 44	Feb. 11, June 21, Oct. 29	...	...	W.
T Capricorni	9.0	21 14 13	105 45	Jan. 24, Oct. 25	...	...	S.
R Pegasi	8.5	22 59 37	80 14	April 15	...	...	A.
R Aquarii	7.0	23 37 15	106 3	June 13	...	...	—
R Cassiopeiæ	6.0	23 51 18	39 23	Sept. 4.	At minimum, March 20	...	P.

*Minima of the Short-Period Variable Stars during 1861 in
G.M.T., and for the Earth's Mean Distance from each
Star.*

Algol.

Maximum 2.3; Minimum 4.0. Whole variation completed in seven hours.

Jan.		d h m	Jan.		d h m	Feb.		d h m	Feb. 24		d h m
3	16	50	23	18	32	4	5	48	24	7	30
6	13	39	26	15	21	15	17	3	10	15	34
9	10	28	29	12	10	18	13	52	13	12	23
12	7	17	Feb. 1	8	59	21	10	41	16	9	12

B

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	d	h	m		d	h	m		d	h	m		d	h	m
April 2	14	5		June 27	14	31		Sept. 21	14	57		Nov. 12	5	37	
5	10	54		30	11	20		24	11	46		23	16	52	
8	7	43		July 20	13	2		27	8	35		26	13	41	
22	15	47		23	9	51		Oct. 11	16	39		29	10	30	
25	12	36		Aug. 9	14	44		14	13	28		Dec. 2	7	19	
28	9	25		12	11	33		17	10	17		5	4	7	
May 15	14	18		15	8	22		20	7	6		13	18	34	
18	11	7		29	16	26		Oct. 31	18	21		16	15	23	
21	7	56		Sept. 1	13	15		Nov. 3	15	10		19	12	12	
June 7	12	49		4	10	4		6	11	59		22	9	1	
0	9	38		7	6	53		9	8	48		25	5	50	

α Tauri.

Maximum 4^o
Minimum 4⁵
Variation rapid.

	d	h	m
Jan. 1	13	4	
5	11	57	
9	10	49	
13	9	41	
17	8	33	
21	7	25	
25	6	18	
April 14	7	41	
Aug. 30	16	28	
Sept. 3	15	0	
7	13	53	
11	12	45	
15	11	37	
19	10	29	
Nov. 17	17	32	
21	16	24	
25	15	17	
29	14	9	
Dec. 3	13	1	
7	11	53	
11	10	45	
15	9	38	
19	8	30	
23	7	22	
27	6	14	

ζ Geminorum.

Maximum 3⁸
Minimum 4⁵
Increasing 5⁴ 6¹.

	d	h	m
Jan. 9	15	0	
Feb. 19	6	12	
Mar. 1	10	0	
11	13	48	
May 1	8	48	
Sept. 20	14	0	
Nov. 10	9	0	
20	12	48	
30	16	36	

δ Cancri.

Maximum 8^o
Minimum 10⁵
Variation rapid.
R.A. 8^h 35^m 56^s
N.P.D. 70° 28'.

	d	h	m
Jan. 6	10	4	
25	9	18	
Feb. 13	8	32	
Mar. 4	7	46	
Dec. 4	8	36	
23	7	50	

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β Lyre.			α Aquilæ.			δ Cephei.				
Principal Minimum 4 ^h 1 ^m			Maximum 3 ^h 6 ^m Minimum 4 ^h 4 ^m Increasing 2 ^d 9 ^h .			Maximum 3 ^h 7 ^m Minimum 4 ^h 8 ^m Increasing 1 ^d 14 ^h .				
Second Minimum (3 ^h 4 ^m)	Second Maximum (3 ^h 8 ^m)	First Maximum (3 ^h 4 ^m)	Feb.	^d 16	^h 18	^m 7	Jan.	^d 3	^h 12	^m 34
				24	15	17		14	6	9
				29	12	28		19	14	57
			June	11	13	52		30	8	32
			July	17	11	2	Feb.	15	10	55
				24	15	16	Mar.	3	13	18
			Aug.	22	8	13		14	6	54
				29	12	27		19	15	41
			Oct.	4	9	37		30	9	17
			Nov.	9	6	47	April	15	11	40
			Dec.	15	3	58	May	1	14	3
								28	10	1
							June	13	12	24
								29	14	47
							July	26	10	45
							Aug.	11	13	8
							Sept.	7	9	7
								23	11	30
							Oct.	9	13	53
								20	7	28
							Nov.	5	9	51
								21	12	14
							Dec.	2	5	49
								7	14	37
								18	8	12

The corrections to be applied to the observed times before comparing with the Ephemeris may be found by the formulæ in the *Monthly Notices*, vol. xvii. p. 27.

The Ephemeris is, for the most part, based upon the same elements of variation as that of last year. For some of the stars, however, I am indebted to Mr. Baxendell and Dr. Winnecke for their valuable contributions of more correct times than I could otherwise have supplied. In a few cases, when two authorities were nearly coincident, the mean has been adopted; or when widely different, both have been given, as limits.

I have again to express my deep regret at the delay of this annual paper, caused by my unforeseen change of position and all its attendant hindrances; but I will endeavour to supply the Ephemeris for 1862 before the close of the current year.

The Hartwell Variable Star Atlas, commenced and far

advanced during my two years' management of Dr. Lee's Observatory, in England, has of course suffered a temporary check, but will be continued and completed here as speedily as possible.

I find I have overlooked one star recently discovered by Mr. Baxendell, and called by him *R Sagittæ*. Its place for 1860 is R.A. $20^h 7^m 40^s$, N.P.D. $73^\circ 42'$; its range of variation from 8.4 to 10.2 magnitudes; and its minimum, in the present year, will be due on March 10, May 21, July 31, Oct. 11, Dec. 21.

Madras Observatory, 1861, March 27.

Discovery of a New Comet.

The following observations have been made at this Observatory, by Mr. Ferguson, of a Comet discovered on the night of the 4th of the present month, at the Observatory of Mr. Rutherford in New York, by Mr. A. E. Thatcher.

	M.T. Washington.	R.A.	Decl.
	^h _h ^m _m ^s _s	^h _h ^m _m ^s _s	[°] _° ['] _' ["] _"
April 10	10 10 20.6	17 7 56.71	+ 59 26 13.53
11	8 38 9.5	17 2 32.55	+ 60 7 20.53

The Comet is circular; about two minutes in diameter, condensed at the centre, and with some appearance of a nucleus.

Observatory, Washington, April 12, 1861.

The Astronomer Royal has received from Mr. Thatcher, by letter dated 1861, April 21, the following account of the discovery and early observations of the same Comet:—

"I discovered this Comet on April 4, $11^h 12^m$, in the head of *Draco*, and fixed its place by the neighbouring stars; its approximate place was—

R.A. $17^h 40^m$	North Declination 57°
On April 10, $11^h 34^m 42^s$, its place was	
R.A. $17^h 7^m 42^s.76$	North Declination $59^\circ 30' 8''$
On April 14 (hour not given)	
R.A. $16^h 36^m$	North Declination 63°
On April 20, 10^h	
R.A. $15^h 40^m$	North Declination 68°

"Its brilliancy has remained nearly the same from April 9 to 20; on the 20th it appeared, with an aperture of $4\frac{1}{2}$ inches and power of 30, as bright as the cluster in the sword-handle of *Perseus*, or the nebula of *Cancer*, to the unassisted eye; and with a diameter of 3'."

No details are given as to the method of fixing the Comet's place on April 10, 14, or 20.

It appears by a letter from Mr. Parkin, dated St. John's Wood, Regent's Park, May 1st, that the Comet was seen by him on the night of April 29th at $11^h 45^m$; estimated right ascension $11^h 20^m$, declination $61^\circ 30'$; and on the night of May 1st, with the naked eye, the position then being right ascension $10^h 45^m$, declination $55^\circ 20'$.

Extract of a Letter from M. Le Verrier to Mr. Hind.

"I do not know if you have remarked in the *Astronomische Nachrichten* that Mr. Lehmann insists that 0'0000005 must be added to the radii-vectores of *Mercury* calculated from my Tables.

"It is a mistake; Mr. Lehmann has not understood that if the alteration he proposes were admitted it would be necessary to change in the same ratio the Earth's distance from the Sun, and thus nothing would be altered in the apparent positions of the bodies. The unit is arbitrary, and Mr. Lehmann does not appear to have a clear conception of that which is adopted in astronomical practice.

"If you think proper to communicate this note to the Royal Astronomical Society, I beg you to do so."

The Minor Planets (88) and (84) have been named *Ausonia* and *Angelina* respectively; the latter name refers to Zach's Astronomical Station at Notre Dame des Anges, near Marseilles. The name *Maximiliana* has been proposed for the Minor Planet (86).

The figures 1 and 3 in Mr. Birt's paper on the "Apparent Rotation of a Solar Spot," pp. 144 and 146, are incorrectly placed. Figure 1 should be turned round in its own plane through a right angle, so as to bring the right-hand side uppermost, and figure 3 should be turned round through two right angles.

It has been pointed out to the Editor that the numbers in Mr. Drach's auxiliary table for the calculation of the log. sin. and log. tan. of small arcs in the last number of the *Monthly Notices*, pp. 147-152, are to be found in Callet's Tables, and elsewhere. Also that a method of finding the latitude without a clock, by means of an altazimuth, similar to that alluded to by M. Radau, p. 168, is given by M. Littrow, *Memoirs*, t. ii., pp. 321-324 (1826).

MISCELLANEOUS INTELLIGENCE.

Mr. Lassell desires to intimate that in consequence of his going to Malta this summer with his large Equatoreal, his smaller telescopes are to be disposed of; and as *they must be taken down and removed* within the next two or three months, he wishes to dispose of them as early as he can.

The smaller of these is the 9-inch Equatoreal, described in the twelfth volume of the *Memoirs of the Royal Astronomical Society*. The larger is the 2-foot Equatoreal, in part described in the eighteenth volume of the above work, and is the telescope with which the former Maltese observations were made. Both these telescopes are in the most perfect and durable order and condition; and their optical performance is, he believes, sensibly perfect to the most fastidious eye; and excepting that the 9-inch has never had a clock-work driving-motion applied, all the conveniences which frequent use could suggest have been successively added.

Mr. Lassell will be glad to answer any inquiries respecting either or both telescopes which a purchaser may wish to make.

*Bradstones, Sandfield Park, near Liverpool,
23d April, 1861.*

RECENT PUBLICATIONS.

The twelfth volume of the *Smithsonian Contributions to Knowledge* contains an account by Lieut. Gilliss of the Total Eclipse of the Sun on Sept. 7th, 1858, as observed near Olmos in Peru, (see *Monthly Notices*, vol. xx. p. 298) and also the

Astronomical Observations in the Arctic Seas by the late Dr. Kane, made during the Second Grinnell Expedition in search of Sir John Franklin in 1853, 1854, and 1855, at Van Rensselaer Harbour and other points in the vicinity of the north-west coast of Greenland, reduced and discussed by Charles A. Schott. The observations determine the latitudes and longitudes of Van Rensselaer Harbour and various other stations, and appended to the paper is a map based on the astronomical results.

Handbuch der Kugelfunctionen. Von Dr. E. Heine,
8vo. Berlin, 1861.

The work is intended to be as well an introduction to as a systematic exposition of the theory of the class of functions commonly called Laplace's functions (but originating in Legendre's functions of a single variable) which play so important a part in the theories of attraction and the figure of the earth, and in other parts of mathematical physics. The author has consulted, and in part reproduced, the investigations of the last-named two geometers, and of Gauss, Jacobi, Lejeune-Dirichlet, Green, Neumann, Lamé, and others, and his treatise appears to be a most valuable monograph on this part of mathematics. It may be remarked that the term Kugel-function (sphere-function) employed by him after Gauss, is somewhat too restricted, as the researches of, in particular, Neumann and Lamé relate to ellipsoids of revolution and of three unequal axes. The latter part of the work comprises applications to the theory of mechanical quadratures (after Gauss) and to the theories of attraction and heat.

The Mathematical Works of Isaac Barrow, D.D. Edited for Trinity College by W. Whewell, D.D., Cambridge, 1860.

The principal contents of the volume are the Lectures which Barrow delivered as Lucasian Professor of Mathematics, an office which he held from 1664 to 1670. And these consist of three series,—the *Lectiones Mathematicæ*, the *Lectiones Opticæ*, and the *Lectiones Geometricæ*; the first being on the general principles of mathematics, the second containing propositions of optics proved geometrically, and the third, treating of properties of curve lines. The volume contains also the preface and dedication to Barrow's edition of Euclid, and the preface to his edition of the works of Archimedes, Apollonius, and Theodosius.

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MONTHLY NOTICES
OF THE
ROYAL ASTRONOMICAL SOCIETY.

VOL. XXI.

May 10, 1861.

No. 7.

Dr. LEE, President, in the Chair.

E. D. Johnson, Esq., 9 Wilmington Square;
Rev. R. C. Lumsden, Sheffield;
Basil Woodd Smith, Esq., Hampstead; and
R. C. May, Esq., Great George Street, Westminster,
were balloted for and duly elected Fellows of the Society.

On the Light of the Sun, Moon, Jupiter, and Venus. By
G. P. Bond, Director of the Observatory of Harvard
College.

In a memoir recently communicated to the American Academy of Arts and Sciences I have given an account of experiments made at the Observatory, during the past year, upon the light of the Sun, Moon, *Jupiter*, and *Venus*. Attention was originally directed to the subject by the remarkable photographic intensity of the light of *Jupiter*, which was first noticed in March, 1851. This property has also been recognised by Mr. De La Rue, who has described his experiments in the *Monthly Notices* of the Royal Astronomical Society, vol. xviii. p. 55. I have found that the reflective capacity of the surface of *Jupiter* for the photographic rays is fourteen times greater than that of the Moon: in other words, out of

an equal quantity of light incident upon each of the two bodies *Jupiter* reflects fourteen times more of the chemical rays than the Moon does. Hence we have,

$$\frac{\text{Photographic albedo of Moon}}{\text{Photographic albedo of Jupiter}} = \frac{1}{14}$$

I am satisfied that no considerable difference of colour, such as has been supposed by De La Rue, exists in the light of the two bodies—certainly none sufficient to account for their very unequal chemical action. From several trials made for the purpose, it would seem that the reflective capacity of the Moon's surface for the photographic rays is not inferior to that of the objects which give the prevailing tone of light to a landscape-view on the earth. On the other hand, no opaque substance has been found capable of reflecting light sufficient to act upon the plate with the same rapidity as *Jupiter*, when the illumination to which both objects are exposed is reduced to the same intensity.

The experiments, though liable to the uncertainty incident to all photometric measurements, are sufficient to prove an excess of photographic intensity in the light of the planet not susceptible of any ready explanation. They have suggested a series of comparisons of the optical intensity of the light of the bodies in question, which have led to the conclusion that the whiteness (*albedo*) of the surface of *Jupiter* exceeds that of any known opaque substance. Even the dusky belts give more light than an equal area of new-fallen snow would do if exposed to the same intensity of solar illumination. The fact is the more remarkable from the circumstance that occasionally white streaks and minute bright spots have been seen upon its disk much more brilliant than the general surface.

In a question where disturbing influences so easily mislead the judgment, it is desirable to bring together the results of different methods of examination. The following affords, perhaps, the most decisive confirmation of the fact of the superior brilliancy of *Jupiter*. I have found, from my own observations, the photometric proportion

$$\frac{\text{Jupiter at mean opposition}}{\text{Mean full Moon}} = \frac{1}{6430}$$

which is confirmed by the results of Sir J. F. W. Herschel's valuable collection of photometric comparisons made at the Cape of Good Hope, giving

$$\frac{\text{Jupiter at mean opposition}}{\text{Mean full Moon}} = \frac{1}{6620}$$

This is derived, not from actual comparisons of *Jupiter* and the Moon, but indirectly from the ratio

$$\frac{\alpha \text{ Centauri}}{\text{Mean full Moon}} = \frac{1}{41400'}$$

differing from Herschel's result published in his *Outlines of Astronomy*, principally on account of a change introduced into the corrections applied to the light of the several phases of the Moon to reduce them to the full phase, which will be more fully explained presently. For the relation between α Centauri and α Lyrae, we have

$$\text{Log. } \frac{\alpha \text{ Centauri}}{\alpha \text{ Lyrae}} = 0.1200,$$

derived from determinations by Seidel and Herschel. Seidel* has obtained, from a very complete discussion of the subject, the values

$$\text{Log. } \frac{\text{Sun}}{\alpha \text{ Lyrae}} = 10.4499 - \text{log. albedo Jupiter},$$

$$\text{Log. } \frac{\text{Jupiter at mean opposition}}{\alpha \text{ Lyrae}} = 0.9158.$$

From the above numbers we obtain

$$\text{Albedo of Jupiter} = \frac{532000}{S}$$

where S is the ratio between the light of the Sun and of the mean full Moon. If, now, we substitute in this last result the value

$$S = 550000,$$

which is the mean between the determinations by Bouguer and Wollaston, we find

$$\text{Albedo of Jupiter} = 0.967,$$

or more than double that attributed by Lambert to a surface of the finest white lead (cremnitz white), which gave the highest albedo, viz., 0.423, of any substance experimented upon by him.

* Untersuchungen über die Lichtstärke der Planeten *Venus*, *Mars*, *Jupiter* und *Saturn*. 4^o Munich, 1859.

The values attributed to *S* by Bouguer and Wollaston, viz.,

$$\begin{aligned} S &= 300'000 \text{ by Bouguer,} \\ S &= 810'072 \text{ by Wollaston,} \end{aligned}$$

are certainly very discordant, though not more so, perhaps, than the difficulties attending the subject would lead us to expect. A new determination, which I have made by a method differing from those employed by them, gives

$$S = 470'980.$$

I have made use of the Bengola light as an intermediate standard of comparison, the colour of its light agreeing very closely with that of moonlight. The observations upon the intensity of moonlight give

$$\begin{aligned} \text{Albedo of Moon} &= \frac{45'193}{S} \\ \text{,,} \quad \text{,,} &= \frac{1}{12'2} \text{ for } S = 550'000, \\ \text{,,} \quad \text{,,} &= \frac{1}{10'4} \text{ ,, } S = 470'980, \end{aligned}$$

for the relative albedos of the Moon and *Jupiter*.

$$\frac{\text{Albedo of Moon}}{\text{Albedo of Jupiter}} = \frac{1}{11'47},$$

and, consequently, for *Jupiter* an albedo of very nearly unity, if we take $\frac{1}{11}$ as the albedo of the Moon. Thus all the data indicate a remarkable excess of brilliancy in the light of *Jupiter*.

For the relative albedos of *Venus* and *Jupiter*, I have found the proportion $\frac{1}{1'10}$. Seidel gives $\frac{1}{1'044}$ for the same ratio. I am inclined to think, however, that the albedo of *Venus* is, in both instances, estimated too high, since it depends mainly upon observations made near the epoch of greatest brilliancy, or between that point and the inferior conjunction, where the illuminated phase occupies but a small part of the disk. The line of incidence and reflection thus approaches the direction of a tangent to the surface; and, as a necessary consequence, the tendency to regular reflection in an opaque surface so presented will have the effect of increasing the quantity of light received from the crescent phases, especially as the planet approaches inferior conjunction.

It is not possible to estimate the amount of light regularly reflected; but there can be no doubt that Lambert's phase-formula, which has been employed in the reductions, will give, on this account, a sensibly higher albedo from observations at the narrow crescents than would be obtained from other phases.* Seidel's observations contain a confirmation of this inference.

In comparing the light of the Moon with the light emitted through a small aperture in a screen placed in front of the flame of a Carcel lamp, arranged with a view to secure a constant standard of illumination, I have obtained the following values of the logarithms of the quantity of light received from its various phases: v represents the angle of elongation of the Moon from the Sun, and H_0 the relative quantity of moon-light from the corresponding phase, taking the light of the mean full Moon as the unit.

$v =$	0°	Log. $H_0 =$	$-\infty$
	20	„	7.224
	40	„	8.049
	60	„	8.574
	80	„	8.974
	100	„	9.291
	120	„	9.551
	140	„	9.763
	160	„	9.931
	180	„	$= 0.000$

The observations have been freed from the effect of atmospheric extinction, and reduced to the mean distance of the Moon from the Earth and Sun.

Herschel's photometric observations made at the Cape of Good Hope upon the light of the Moon and of various fixed stars have furnished, after reduction, the following comparisons with value of $\log. H_0$ taken from the above table —

v	Log. H_0 .	Cape Obs.	Diff.	Wt.
$v = 102.2$	9.324	9.368	-0.004	7
121.7	9.574	9.560	$+0.014$	8
131.3	9.681	9.711	$+0.030$	9
135.7	9.724	9.725	-0.001	9

* It is well known that *Venus* is visible in the day time to the naked eye, at near the time of its greatest brightness. I have often seen *Jupiter* with the naked eye while the sun was high above the horizon and shining clearly; and, on one occasion, *Sirius*. From the readiness with which the latter could be discerned, in a position where much of its light must have been lost by atmospheric extinction, I should think it possible to see *Lyra* also under favourable circumstances.

	Log. H_0	Cape Obs.	Diff.	Wt.
$v = 143.7$	9.805	9.778	+0.027	10
158.7	9.920	9.868	+0.052	13
167.0	9.964	9.991	-0.027	6
179.3	0.000	0.157	-0.157	2

With the exception of the last difference, depending upon an isolated observation made under unfavourable circumstances, there is a good agreement between the two series. The present reduction of the *Cape Observations* has been made without regard to Herschel's hypothesis respecting the impression made by the light of the stars upon the eye, as influenced by a change in the illumination of the background of the sky by varying amounts of moonlight, viz., that "the effective impression of a star on the retina is inversely as the square of the illumination of the ground of the sky on which it is seen projected."*

From the manner in which our values of log. H_0 have been obtained, they could not have been affected by this condition; and their accordance with the *Cape Observations*, uncorrected by the hypothesis, shows very clearly that the latter is not necessary to satisfy the observations. And yet it is remarkable that Herschel should have been able, by means of it, to represent completely a large series of observations otherwise wholly discordant. From a full investigation of the subject, the details of which are presented in the memoir, it appears that the true explanation of the discrepancies noticed by Herschel is to be found in the anomalous manner in which the Moon reflects light to the Earth from its different phases, in consequence of which the quantity of moonlight increases much more rapidly towards full-moon, compared with the phases on either side of it, than can be accounted for by the formulæ of Lambert or of Euler—so much so that, taking the full-moon as a standard, even Lambert's, which accords best with observation, makes the observed light at quadrature from two to three times fainter than is indicated by the theory.

Herschel's formula for the relative enfeeblement of the light of the stars, while it affords a very precise representation between quadratures and full-moon, if interpreted as a consequence of an actual variation of the amount of moonlight, is perfectly consistent with the results of my own investigation for the limits including the observations which have been discussed by him.

The following are the results of a comparison of the logarithms of the observed amounts of mean moonlight at different angles of elongation; v , the unit, being the amount from the

* *Results of Astronomical Observations made at the Cape of Good Hope*, p. 356.

mean full-moon for which $v_0 = 180^\circ$, with the logarithms computed from the formulæ of Lambert and Euler, and from an empirical formula, in which the light is assumed to vary as $\sin^6 \cdot \frac{1}{2} v$, which differs scarcely sensibly in its results from Herschel's formula under the above construction of its significance. It will be seen that the latter accords well with observation up to about $v = 90^\circ$, and suddenly diverges from a correct representation between new and half-moon, phases which were not included among the *Cape Observations*.

v	Obs'd. Moonlight.	Lambert. Euler and Herschel.		Log. $\sin^2 \frac{1}{2} v$.
	Log. H_0 .	Log. $\frac{\sin v - v \cos v}{\sin v_0 - v_0 \cos v_0}$	Log. $\sin^2 \frac{1}{2} v$.	
$v = 0$	$-\infty$	$-\infty$	$-\infty$	$-\infty$
20	7'224	7'653	8'479	5'438
40	8'049	8'536	9'068	7'204
60	8'574	9'037	9'398	8'194
80	8'974	9'374	9'616	8'848
100	9'291	9'613	9'768	9'305
120	9'551	9'785	9'875	9'625
140	9'769	9'903	9'946	9'838
160	9'931	9'975	9'987	9'960
180	0'000	0'000	0'000	0'000

On the Spiral Structure of the Great Nebula of Orion. By
G. P. Bond, Esq., Director of the Observatory of Harvard
College.

A disposition in the light of this nebula to radiate outwards and in a southerly direction from the neighbourhood of the *trapezium*, is noticed in my father's memoir, published in 1848, in which are named, as particular localities, Herschel's subnebulous region and the preceding side of the *Regio Huygeniana*. This peculiarity has since attracted attention on many occasions; but it is only recently that it has been subjected to a minute and systematic examination, the results of which I propose now to communicate.

In the season of 1857-58 I undertook the formation of a catalogue of the stars comprised within a square of $40'$ having δ *Orionis* as its centre. One hundred and twenty-one of the brighter stars were selected, and their positions determined, to serve as points of reference for filling in the remainder, which were mostly too faint for observation under a strong illumination of the micrometer wires. This was completed in 1858. The order of magnitude of the stars was subsequently made

the subject of careful study by the method of sequences described by Sir John Herschel in the "Results of Astronomical Observations made at the Cape of Good Hope." The whole number of stars included up to the end of the season, 1857-58, was two hundred and sixty-two; but it must be remembered that innumerable fainter stars have been omitted, on account of the difficulty of observation, and many of them appearing only on occasions of the finest definition.

In the following year, 1858-59, the area above indicated was divided into four charts, on which the outlines of the nebulosity were traced in chalk and white water-colour, laid on a dark ground. These were next combined in a single drawing, which was subsequently compared with the nebula, and corrected. The particular feature, which it is now proposed to describe, did not, however, present itself in its full force until the present year. During the months of December, January, February, and March last, favourable opportunities were taken to review the whole region, with particular reference to the arrangement of the nebulosity in long wisps, alternating with darker spaces sweeping outwards from the vicinity of the *trapezium*. A careful scrutiny of the intermediate dark channels was of considerable assistance in tracing the fainter convolutions.

The form and dispositions of the whirls were thus defined by two independent processes, the nebula being first sketched as a bright object on a dark ground, and again, its darker openings and channels as dark objects on a bright ground.

The quarter designated in Herschel's chart* as the *Regio Godiniana* was first explored. The nebulosity was here resolved into an assemblage of three or four long wisps, interlaced with each other, or crossed by off-sets, which were ultimately traced from a point near the northern margin of the *Sinus Magnus*, over the whole length of the *Regio Picardiana* and the *Regio Godiniana*, forming a sweep of 120° . After passing the well-defined northern boundary of the last-named region, and beyond Herschel's stars α and ξ , these wreaths bend rather suddenly, and tend towards the south preceding direction. Indications of their presence in this quarter are imperfectly suggested in Lassell's and in Sir J. Herschel's latest drawing. From this point feeble traces exist for $10'$ or $15'$ in a south preceding direction. Their course over the *R. Picardiana* gives a decidedly reticulated aspect to the whole region; but, though bright, they are here so closely intertwined and connected by off-sets, that it is a matter of no little difficulty to gain a clear comprehension of their proper relations. The complexity of the details is further increased by several off-shoots from this quarter, which cross over into the adjacent *R. Derhamiana*; still the general effect is easily recognised.

* *Mem. Ast. Soc.* vol. ii.

From the southern corner of the *Regio Picardiana*, and from those parts of *R. Derhamiana* and *R. Huygeniana*, which lie near the *trapezium*, on its north preceding and preceding sides, a number of narrow and bright branches diverge, their extremities tending also to the south preceding direction. Some of these cross the *R. Gentiliana*, and seem to merge together, forming a nebulous mass, which can be followed through an arc of $10'$ or $15'$. Others, which are less curved, originate near the *Sinus Gentilii*; these are narrow and somewhat tortuous.

It is to be noticed that the initial direction of the wreaths (*Nebelstreifen*) changes continuously from an angle of position of 330° , on the northern margin of the *Sinus Magnus*, to one of 220° , or less, at the *S. Gentilii*, and the sweep of the curve correspondingly diminishes, so that throughout the whole nebulous region preceding the sharply-defined apex of the *R. Huygeniana*, the extremities of the filaments have a pretty uniform tendency in the angle of position, 220° . As soon, however, as we pass to the fields on the following side of the apex, a change is immediately apparent; the ultimate direction being about in the angle 160° . The principal group of wisps results from the resolution of the *R. Messeniana*, and the region between the *trapezium* and the *Proboscis Minor*, including both these features, into four or five distinct wreaths, having a common initial direction in the angle of position 110° . The very bright nebulosity lying between the *S. Gentilii*, the *trapezium*, and the *R. Subnebulosa*, cannot be resolved into a regular structure, but three or four condensed spots, constituting the most brilliant part of the nebula, close on the south preceding side of the *trapezium*, are plainly distinguished as tufts or curled off-sets from a prominent wisp of light, which extends from its origin near the *trapezium* across the *R. Gentiliana*.

The general aspect of the greater part of the nebula is, therefore, that of an assemblage of curved wisps of luminous matter, which, branching outward from a common origin in the bright masses in the vicinity of the *trapezium*, sweep towards a southerly direction, on either side of an axis, passing through the apex of the *Regio Huygeniana*, nearly in the angle of position 180° . About twenty of these convolutions have been distinctly traced, while others, giving a like impression, are too faint or too intricate to be subjected to precise description. It may, in fact, be properly classed among the "spiral nebulae," under the definition given by their first discoverer, Lord Rosse; including in the term all objects in which a curvilinear arrangement, not consisting of regular re-entering curves, may be detected.

That the existence of this feature in the great nebula of *Orion* should have hitherto escaped notice, after the many careful scrutinies to which it has been subjected with the help of the largest instruments and the most skilful observers, may

seem scarcely credible. A few words of explanation on this point will not, therefore, be amiss. It is to be ascribed partly to the confusing effect produced by the crossing and intersection of the principal striæ and of their off-sets, which the eye cannot unravel without the aid of some clue to their mutual relation and significance, and partly also to the faintness of some of the details, which are, nevertheless, very essential features in a correct apprehension of its structure, supplying, as they do, what would otherwise appear as breaks of continuity, and assisting materially in the recognition of a principle of regularity pervading the whole structure. Until the law of relation and continuity in the several parts of such an object is entertained in the mind, it must remain an incoherent, confused assemblage of material, having no orderly or connected arrangement.

The change from the previous notion of its configuration is not more considerable than that which took place with reference to the celebrated nebula 51 *Messier*, in which the original discovery of the spiral arrangement was made. This object had been subjected to a careful examination and description by both the Herschels; but neither their drawings nor descriptions furnished the slightest intimation of a spiral structure. It deserves particular notice, too, that there was no want of sufficient optical power to exhibit the appearance in question; for the spirality is seen with perfect distinctness in a refractor of 15 inches aperture, and must certainly be within reach of the 20-foot Herschelians reflectors. Nor can it for a moment be thought that the earlier observations and delineations were in any proper sense erroneous. They were simply made at a great disadvantage in the absence of a clear conception of the general plan of structure presented in the object. Some of the details indispensable to its recognition, being only faintly presented, were overlooked, or, appearing by mere suggestions and glimpses of vision, they conveyed an erroneous impression: in this way the mutual relation of the various parts came to be entirely misconceived. The missing links were supplied by the larger optical power of Lord Rosse's telescope, too plainly not to insure notice; and the nebula then presented itself under a totally different aspect. Instances of similar revelations, completely at variance with previous conjectures, have indeed so often occurred in the history of astronomical discovery, that the process ought to be regarded as the ordinary rule rather than as an unusual exception.

There are several other features of minor importance which have engaged attention in the course of this survey of the nebula. One of these is the large number of instances in which collections of nebulous matter are found associated with stars, frequently in the form of little wisps, shooting off in a southerly or south preceding direction. Another is the predominance of small stars in the nebulous regions. Two

remarkable instances occur where there is a deficiency of nebulous matter in close proximity to bright stars, which are yet closely encircled by it. These are the bright groups of the *trapezium*, the central comparative darkness of which has been noticed by many observers, and *Orionis*. Lord Rosse's figure of the latter is decisive in this point. These features seem to favour the idea of a physical association of the stars with the nebula. The existence of a spiral arrangement of its component parts falls in with the suggestion of a stellar constitution, since, among the objects exhibiting this peculiarity, are included, not only resolvable nebulae, but actual star-clusters, such, for instance, as the great cluster in *Hercules*, which has an unquestionable curvilinear sweep in the disposition of its exterior stars.

On the Morning Illumination of the Western Portion of the Mare Humorum. By W. R. Birt, Esq.

In the communication which I had the honour of submitting to the Society at its last meeting, I solicited attention to the appearance of those craters that, standing near the borders of the *Mare Humorum*, had had those portions of their walls broken down that faced the *Mare*. As an admirable opportunity occurred on the evening of April 20th, 1861, of noticing the morning illumination of the western portion of the surface of the *Mare*, which presented some features, perhaps interestingly connected with those that have already claimed attention, some of which appear to be but obscurely indicated in Beer and Mädler's map, I have considered it important to submit to the Society my observations of them as a further contribution to the selenography of this part of the Moon's surface.

At 7^h 15^m G.M. T., April 20, 1861, the terminator crossed the *Mare*, extending from the western flank of *Gassendi* to the western wall of *Vitello*, the interior of the eastern wall of which was very brilliant, its floor as well as the included mountain being in perfect darkness.

The western flank of *Gassendi* appeared to be very rugged, a portion only of the summit of the south-west wall was seen projecting into the night side of the Moon; this illuminated portion terminated abruptly, the last peak being detached. To this detached peak, which Beer and Mädler mark *4*, I beg to solicit attention presently.

On the surface of the *Mare* between the line across it, joining the two ringed mountains above named, and its western borders, including the arm on which *Hippalus* stands, occur

some interesting *curved* ridges, the convexities of the curves being directed invariably towards the border of the *Mare*, as if they had resulted from the operation of a force that had so acted as to elevate them in some degree *parallel* with the border, *the least parallelism occurring towards the centre of the Mare*. These ridges are true elevations above the surface, casting well-defined shadows. In describing them for the sake of easy reference, I append to each a Roman numeral.

I. This ridge is at this epoch of illumination nearest the terminator; it takes its rise at its southern extremity from the point of intersection between the eastern wall of the ring of *Vitello* and the western of the large disrupted crater, mentioned in my last communication, and runs with a slight divergence from parallelism with the terminator, for about one-fifth of the breadth of the *Mare*, *i. e.* from *Vitello* to *Gassendi*. At this point, marked δ by Beer and Mädler, it abruptly changes its direction, running here towards the north-west, casting a considerable shadow; and, from a later period of the observations, this part would appear to be the western ring of a nearly *obliterated* crater greatly ruined. The ridge terminates *in a point against* a small crater marked D in Beer and Mädler's map. *The crater is perfectly detached from this point, and appears to have been elevated on the southern extremity of a ridge, forming a continuation of the foregoing*, and extending about half-way across the *Mare*. The crater is more elevated than the ridge, and casts a well-defined shadow. I have italicised the position of the crater D, as Beer and Mädler's map exhibits a *continuous* ridge.

II. and III. Westward of I. two ridges take their rise respectively from two mountains north of *Vitello*, marked by Beer and Mädler as two craters E and F, the eastern F being very near the ridge I, and the western E north-west of *Vitello*, and north-east of a small crater on the surface of the *Mare*, just within its south-west mountainous boundary, not given by Beer and Mädler, unless the crater E be it; in which case we have no mountain on the map. These two ridges, the rise of which from the mountains or craters are not given by Beer and Mädler, *converge*, and with more or less sinuosity skirt the ridge I, both receding considerably from it in the neighbourhood of the crater D, well shown by Beer and Mädler, with one between, which was not apparent to me on the evening of the 20th. In this part of their course they form considerable *bends* around the crater D, both apices of the bends being in a line with the crater.* A little to the north

* On consulting Beer and Mädler's map, I find the crater D, the apices of the bends of the ridges, and the partially destroyed crater *Hippalus*, *in the same line*. I shall look, should I have the opportunity on a future occasion, with great interest for an ocular confirmation of this. 1861, May 20, 11 to 12 hours; *Hippalus* is in the same line with the bends and crater D, but not that portion of the wall that appears to have been destroyed.

of these bends, the ridges II. and III. unite, and proceed to a point nearly midway between two small craters that appear to have been elevated at a period posterior to that of the formation of the surface of the *Mare*. Beer and Mädler mark the eastern crater I, and bring the whole of the united ridges to it. This I failed to see.

Beer and Mädler depict the ridges in this part of the *Mare* as being more numerous than I was able to ascertain. My observations were made without reference to the map. I did not consult it until some days afterwards.

IV. From the westernmost of the two craters just alluded to, a slightly undulating ridge extends to the southern wall of *Gassendi*, and passes into the night side of the Moon as a fine delicate line of light.

As the illumination of the southern wall of *Gassendi* proceeded, the separate peak θ of Beer and Mädler, mentioned above, was seen to occupy a position *slightly within* the general boundary of this portion of the ring of the crater, *as if it had been pushed inwards towards the crater*. This is well depicted by Beer and Mädler. It is at this point that the ridge IV. terminates, apparently resting as a buttress against the dislodged part of the ring, also well shown by Beer and Mädler; the remaining portion of the southern wall of *Gassendi* towards the east attains a much lower altitude, as, during the continuance of the observations, four hours, every part remained in darkness.*

V. and VI. Two somewhat lower ridges extend from the bend of III. to the crater from which IV. takes its rise; one only of these depicted by Beer and Mädler.

The above-described ridges, which were all I was able to see with my instrumental means, are situated on the western part of the *Mare Humorum*; they can hardly, if at all, be regarded as ranges of mountains, but may, I apprehend, be considered as ranges of *low* hills, the wall of the nearly obliterated crater rising to the greatest height. The curve of this wall is not well shown by Beer and Mädler.

Epoch, 1861, April 20^d 37; Moon's age, 10.57. Greatest libration, S.E. + 2^d 64; epoch, April 17^d 17^h 19^m. Perigee, — 3^d 58: epoch, April 23^d 23^h.

* From my observations of May 20, 11 to 12 hours, it would appear that the southern part of the ring is scarcely, if at all, elevated above the surface of the *Mare*.

Phenomena of Jupiter's Satellites observed with the Telescope of the Helimeter, at the Radcliffe Observatory, Oxford.
By the Rev. R. Main.

1861, April 17. While engaged in attempting to complete the adjustment of the half-object-glasses of the helimeter, by means of the image of *Jupiter*, I observed that the 1st and 2d Satellites were approaching each other; and it appeared to me that they would pass very nearly, if not exactly, over each other. I, therefore, continued to watch them till the conjunction took place, and was not disappointed, as they came into actual contact, and covered each other so completely, that only one single object with perfect sphericity was visible.

I first used a power of 150, and when they came very near each other, I put on a power of 200; but with neither was the definition very good, on account of the east wind. I had previously made these images, formed by the halves of the object-glass, cover each other at the zero very satisfactorily.

The following is the observation of time of contact:—

The conjunction appeared to be perfect—that is, I could perceive no defect of sphericity at $12^h 30^m 30^s$ clock time (sidereal.)

I could discern no change up to $12^h 38^m$, when I began to perceive that the image was elongating.

At $12^h 39^m 45^s$, I could perceive that the satellites were separating, though the surfaces were still in contact.

At $12^h 41^m 45^s$, they had separated by a space equal to the diameter of either, the diameters appearing to be very nearly equal.

Satellite I. was approaching *Jupiter*, and Satellite II. was receding from him on the (apparently) west side.

The clock time was 50^s slow of sidereal time.

1861, April 23. *Eclipse (reappearance) of Jupiter's 3d Satellite.*

The satellite was seen, very faint, at $13^h 19^m 15^s$ clock time, and took several seconds to acquire its full brightness. The observation very good.

The clock was slow of sidereal time $1^m 3^s.8$.

Hence Oxford sidereal time of reappearance was $13^h 20^m 18^s.8$, and the mean solar time was $11^h 12^m 25^s.1$.

The Greenwich mean time given in the *Nautical Almanac* is $11^h 15^m 18^s.3$.

April 24. *Eclipse (reappearance) of Jupiter's 2d Satellite.*

The satellite was first seen, exceedingly faint, at $12^h 25^m 13^s$ clock time, and it did not reach its full brightness for more than a minute.

The clock was slow $1^m 5^s.0$.

Hence Oxford sidereal time of reappearance was $11^h 26^m 18^s.0$, and the mean solar time was $10^h 14^m 37^s.2$.

The Greenwich mean time given in the *Nautical Almanac* is $10^h 20^m 18^s.9$.

May 6. Eclipse (reappearance) of Jupiter's 1st Satellite.

The satellite was seen as a very minute point, not brighter than the 12th magnitude, at $12^h 10^m 41^s$ clock time; and I watched it till it seemed to have acquired its full brightness, which was not till $12^h 12^m 30^s$ (though clouds which partially veiled it after the reappearance for a few seconds at a time may have interfered with my judgment).

The clock was $1^m 14^s$ slow.

Hence Oxford sidereal time of reappearance was $12^h 13^m 44^s$, and the mean solar time was $9^h 14^m 54^s.3$.

The Greenwich mean time given in the *Nautical Almanac* is $9^h 18^m 20^s.9$.

A communication was received from Mr. Thomas Barneby, giving an account of the appearance of *Jupiter* and his satellites, as observed on the night of the 5th April, 1861. The shadow of the third satellite was at first seen in the shape of a broad dark streak, such as the cone of the shadow would represent in a slanting direction; but it shortly afterwards appeared as a circular spot, perfectly dark, and much larger than the shadow (which was visible at the same time) of the third satellite. The phenomena were illustrated by a sketch.

Results of Meridional Observations of Small Planets; and of the Observations of Phenomena; made at the Royal Observatory, Greenwich, during the month of April, 1861.

(Communicated by the Astronomer Royal.)

Iris (7).

Mean Solar Time of Observation.	R.A. from Observation.			N.P.D. from Observation.					
	h	m	s	h	m	s	o	'	"
1861, April 16	13	56	8.0	15	36	51.95	113	45	15.68
24	13	18	25.5	15	30	35.66	113	20	38.50

Hebe (8).

Mean Solar Time of Observation.			R.A. from Observation.			N.P.D. from Observation.			
	h	m	s	h	m	s	°	'	"
1861, April 4	9	58	48.6	10	51	34.90	70	48	44.13
5	9	54	22.9	10	51	5.02	70	44	56.99
8	9	41	13.0	10	49	42.62	70	35	39.15
11	9	28	15.2	10	48	32.40	70	28	8.38
16	9	7	8.0	10	47	4.43	70	19	50.36
20	8	50	40.0	10	46	19.76	70	16	48.79
23	8	38	34.8	10	46	2.48	70	16	27.96
24	8	34	34.5	10	45	58.09	70	16	41.50

Parthenope (11).

Mean Solar Time of Observation.			R.A. from Observation.			N.P.D. from Observation.			
	h	m	s	h	m	s	°	'	"
1861, April 4	10	20	33.6	11	13	23.50	79	1	13.75
5	10	15	59.9	11	12	45.57	78	57	20.20
16	9	27	14.5	11	7	14.27	78	28	8.32
20	9	10	14.4	11	5	57.63	78	23	8.99
23	8	57	45.1	11	5	15.93	78	21	28.30
24	8	53	38.6	11	5	5.31	78	21	11.64

Melpomene (19).

Mean Solar Time of Observation.	R. A. from Observation.			N.P.D. from Observation.					
	h	m	s	h	m	s	°	'	"
1861, April 4	7	39	22.7	8	31	46.12	71	46	52.15

Leda (36).

Mean Solar Time of Observation.	R.A. from Observation.			N.P.D. from Observation.					
	h	m	s	h	m	s	°	'	"
1861, April 8	10	46	24.4	11	55	4.79	100	55	37.03

Lætitia (30).

Mean Solar Time of Observation.	R.A. from Observation.			N.P.D. from Observation.					
	h	m	s	h	m	s	°	'	"
1861, April 10	11	42	34.1	12	59	16.75	86	6	29.78
16	11	14	37.4	12	54	54.80	85	29	21.28

Eugenia (45).

Mean Solar Time of Observation.		R. A. from Observation.		N.P.D. from Observation.
	h m s		h m s	
1861, April 5	11 39 36.0	12 36 35.39		86 0 32.30
25	10 7 56.5	12 23 31.91		84 18 37.54
27	9 59 8.6	12 22 35.74		84 12 32.81

All the observations of N.P.D. are corrected for refraction and parallax.

The observations of *Angelina* (46), printed in the *Monthly Notice* for April, were made, 1861, March 21 and 22, and not, as there stated, March 15 and 22.

No occultations of Stars by the Moon were observed.

Phenomena of Jupiter's Satellites.

Day of Observation.	Satellite.	Phenomenon.	Mean Solar Time.	Observer.
1861.			h m s	
April 5	IV.	Ingress, first cont.	11 7 58.4	J. C.
5	IV.	„ bisection	11 12 27.7	J. C.
5	IV.	„ last cont.	11 17 56.8	J. C.
5	IV.	„ first cont.	11 8 50.7	N.
5	IV.	„ bisection	11 12 35.1	N.
5	IV.	„ last cont.	11 16 34.4	N.
8	II.	Egress, last cont.	7 47 6.6	A. D.
16	III.	Ecl. reappearance	7 17 45.2	C.
23	III.	Ecl. reappearance (a)	11 16 39.0	E.

(a) The satellite was thought to have reappeared a few seconds before it was seen.

The initials E., C., J. C., A. D., and N., are those of Messrs. Ellis, Criswick, Carpenter, Davis, and Newcomb.

Mr. Carrington's Chronograph.

Mr. Carrington exhibited at the evening Meeting an instrument for the registration of time-signals on a fillet of paper, the parts of which were put in motion that their performance might be inspected in working order. He commenced his explanation by acknowledging the assistance he had received in carrying out his ideas from Mr. C. V. Walker, Telegraph Engineer to the South Eastern Railway Company, who permitted the works to be executed at Tunbridge by the skilled workmen at the clock-factory under his direction.

B

In devising a modified form of Chronograph his object was twofold; 1st, to supply a want felt last summer at Redhill during a period of great solar activity, of the power of recording many more signals in a given time than could be done by the ear, eye, and pencil; 2d, to endeavour to reduce the cost of such an instrument so considerably as to place it within the reach of all observers; for in his intercourse with private astronomers he had frequently become aware of the difficulty found by them in making observations of position where it was required to count and register differences of time with a half-second chronometer.

The parts of the instrument, of which full-size plans will be deposited with the Society, were mainly three; 1st, the reel carrying the fillet; 2dly, the machine for driving and stamping; and 3dly, a sustained pendulum, by which at every vibration a current was allowed to pass from a battery of three cells, and the time-pen of (2) made to register a time scale dot. The reel can require no particular description, but it may be stated that the fillet wound on it was in size and quality similar to that used for the London District Telegraphs, and may readily be procured at an extremely low price in any length and quantity. The pendulum was of a length beating $\frac{6}{10}$ seconds, (in the instrument exhibited) and was accompanied by only so much of the usual clock-train as was necessary for keeping up its vibrations and enabling it to do the work required, of making slight metallic contacts. For this purpose it was crooked at about one-fourth of its length from the point of suspension, and a steel point introduced directed upwards, which at every vibration in passing the lowest point touched a point on the other side of a small doubly inclined plane, placed beneath a horizontal flexible spring. By the momentary contact so made, the duration and delicacy of which was regulable by a screw, two ends of a wire were placed in metallic contact, and a current allowed to pass to the machine (2).

This portion (2) consisted of a train of wheels for driving and regulating the rotation of a narrow drum, over which passed the fillet, which was drawn along at a rate liable to very small variation from under an inking desk, through the bottom of which worked three small platina plungers or wire pens, dropped by the passage of galvanic currents through corresponding pairs of electro-magnets. The regulation of the rate of the driving train was effected by two small centrifugal spring pieces, attached to the circumference of a fly forming the last wheel of the train, and the friction of which against two opposed surfaces admitting of adjustment established and maintained an evenness of rate amply sufficient for the object in view. The arrangement of the inking apparatus is due to Prof. Wheatstone, from whom was borrowed the ingenious idea of drilling holes through the bottom of a metallic disk too

small to admit of the escape of a drop, and through which the plungers or pens descend freely, with their tips constantly moistened by the capillary action of the small holes in which they remain while at rest.

The descent of the middle pen was regulated by the pendulum, and recorded on the fillet a series of centre dots at distances indicating on the scale intervals of time of six-tenths of a second. The other two, which may be termed the A and B pens, are under the control of the observer, who holds in his hand a contact maker, with which either one or the other pen is made to descend instantaneously and record a dot. In Mr. Carrington's method of observing the positions of solar spots, the interval of passage of the Sun's diameter would be represented on the fillet by a length of about $10\frac{1}{2}$ feet, divided into equal intervals, and on one side by the A pen would be recorded the contacts of limbs and spots with pen A, and on the other those of pen B, the unit of measurement employed being of no moment whatever; and it is evident that, wherever two co-ordinates can be observed instantaneously by this or analogous methods, the new Chronograph will be found an aid to the observer. Its especial use is, however, in cases where it is necessary to record with great rapidity, or in the absence of all light, as when a faint object is present in an equatoreal; other previously devised instruments being more suitable for meridional observation.

The machinery and weights of the instrument exhibited cost less than 12*l.*, a part of which was incurred by alterations necessary in a first trial, and with table, battery, and appurtenances, the whole did not exceed 13*l.* The essential parts of the common clock may be purchased in Clerkenwell at prices far less than would commonly be believed till known; and if a clever workman disposed to employ his evenings after usual hours can be met with, experiments similar to those from which resulted the above machine may be tried without very alarming or deterring expense.

Observations and Elements of Comet I., 1861.

(*Extract of a Letter from Mr. Bond to Mr. Carrington.*)

The comet discovered by Mr. A. E. Thatcher, of New York, on April 4th, has been observed here as follows:—

Comet I., 1861.			
	Camb. M.S.T.	R.A.	Decl.
1861.	h m s	h m s	° ' "
April 10	11 34 42	17 7 42.60	+ 59 28 12.8
11	9 27 6	17 2 26.69	60 9 0.2
14	9 1 27	16 40 14.35	62 30 7.1
18	14 21 33	15 49 15.55	65 52 42.9

216 *Observations and Elements of Comet I., 1861.*

On account of an error in the place of the comparison-star, the declination of the comet, April 9th, was erroneously reported to the *Astronomische Nachrichten*, and to the Bulletins of the Paris Observatory, as

$$+ 59^{\circ} 30' 13''.8$$

instead of

$$+ 59^{\circ} 28' 12''.8$$

Mr. Safford has computed the following elements of the Comet:—

T 1861, June 4^h 00^m 4, Washington M.T.

Motion direct.

$$\begin{array}{rcl} \alpha - \Omega = u & \dots\dots & 213^{\circ} 15' 30'' \\ \Omega & \dots\dots\dots & 29^{\circ} 15' 13'' \\ i & \dots\dots\dots & 81^{\circ} 14' 23'' \\ \text{Log } q & \dots\dots & 9.96544. \end{array}$$

Harvard Observatory, April 8, 1860.

Observations of the same Comet. By Sandford Gorton, Esq.

Mr. Gaunt and I observed the Comet at this place on the 4th of May, at 11 P.M. It was visible to the naked eye, appearing like an indistinct star of the 2d or 3d magnitude. It was sufficiently bright to be well seen in the field under an illumination which extinguished stars apparently of the 6th magnitude. In the dark field a tail was readily to be traced, extending in the S. F. quadrant to a distance of about a degree, as far as I could judge. Its rate of progress in declination was so rapid that we watched it approach and pass a star during the hour we were observing.

On the 6th and 8th I again saw it, but with difficulty, owing to the mist.

Last night (the 9th) was also misty, and the comet could scarcely be seen without the telescope.

The following are the approximate positions shown by my

Equatoreal, which, of course, are open to correction by more powerful instruments:—

	G.M.T.	R.A.	Decl.
	^h ^m	^h ^m ^s	[°] [']
May 4	11 0	9 51 10	+45 5
6	12 30	9 27 55	37 10
9	9 35	9 3 35	26 18
"	11 28	9 3 10	25 59½

Telescope, 4 feet focal length; aperture, 3½.

Observatory, Downs Road, Clapton,
May 10, 1861.

Discovery of Minor Planets (66), (67), (68) and (69).

The discoveries of the first three are announced in the *Astronomische Nachrichten*, No. 1308, and Circular of 6 May, 1861, and that of the last in Le Verrier's *Bulletin* of the 13th May, which contains also some later observations of (67) and (69).

Minor Planet (66). Discovered by Mr. H. P. Tuttle at the Observatory of Harvard College, Cambridge, U.S., on the morning of April 10th; magnitude 13. The following positions were obtained from comparisons made by Mr. Bond with a star of the 7-8 mag. W. 1011, occurring also in Santini's Catalogue and the Harvard zones 6 and 7, No. 76.

1861, April 9, 14^h 36^m 23^s Camb. M.T.

R.A.	Par. x Δ.	Decl.	Par. x Δ.
11 ^h 59 ^m 45 ^s .83	+0 ^s .358	+0 [°] 9' 12".7	+5".74
Daily Motion -43 ^s		0 ^s .	

Minor Planet (67), *Leto*. Discovered by Dr. Luther at the Bilk Observatory, at 12½ on the night of the 29th of April, in R.A. 14^h 9^m 35^s, Decl. -11[°] 6' 3"; magnitude 11. The following observation was made,—

	Bilk M.T.	R.A.	Decl.	Comps.
1861, April 29	13 ^h 21 ^m 2 ^s .0	14 ^h 9 ^m 32 ^s .73	-11 [°] 6' 15".1	8
Daily Motion -54 ^s			+2'.2	

The star of comparison being taken from Rumker's Catalogue:

	Mag.	App. Position.	Mean Position, 1861.
April 29	6	214 [°] 0' 6".1 - 11 [°] 4' 53".0	213 [°] 59' 16".6 - 11 [°] 4' 34".2

The name was selected by Prof. Argelander, Dr. Krüger, and M. Tiele, at Bonn.

The following later observations by the discoverer are given in Le Verrier's *Bulletin*:—

	Bilk M.T. h m s	R.A. h m s	Decl. ° ' "	
April 30	10 52 17.5	14 8 44.76	-11 4 5.2	8 comp.
May 7	10 42 19.7	14 2 35.91	-10 48 2.4	10 comp.

Minor Planet (66). Discovered by M. Schiaparelli at the Royal Observatory of Milan, April 29; magnitude 11.

1861.	Milan M.T. h m s	App. R.A. h m s	App. Decl. ° ' "
April 29	11 26 5	10 22 13.83	+7 37 49.9
30	9 16 27	10 22 36.74	+7 38 47.2
May 1	8 53 56	10 23 3.19	+7 39 49.8
2	8 56 36	10 23 30.72	+7 40 36.9
3	9 1 30	10 24 0.02	+7 41 20.7
7	9 3 7	10 26 6.91	+7 42 36.2
8	9 5 56	10 26 41.46	+7 42 36.1
9	8 57 1	10 27 16.66	+7 42 23.4

where the observations on and after the 2d of May are taken from Le Verrier's *Bulletin*.

The planet at the time of its discovery was distant only 9' from *Ausonia* (6), and it was at first taken for that planet.

Minor Planet (66), *Panopea*. Discovered by M. Goldschmidt at Fontenay aux Roses, near Paris, on the 5th of May, mag. 10-11. The following observations have been obtained:

1861.	Paris M.T. h m	R.A. h m s	Decl. ° ' "
May 5	10	14 43 43	-14 20 (a)
10	10 44	14 38 30	-14 21 54 (a)
11	11 45	14 37 25	-14 23 (a)
14	10 10	14 34 16.91	" (a)
14	10 45	14 34 15.30	-14 25 36 (b)
15	10 57	14 33 14.55	" (b)
15	11 29	"	-14 26 19 (b)
16	9 55	14 32 14.8	-14 29 29

(a). Star of Comparison (1800) Berlin Cat. R.A. 14 34 52 Dec. -14 8 3
Reduced for 10 May App. R.A. 14 38 15 Dec. -14 24 26

(b). Star of Comparison (1800) Berlin Cat. R.A. 14 29 56 Dec. -14 27 2
Reduced for 14 May App. R.A. 14 33 19.15 Dec. -14 43 36

The observations of the 14th, 15th, and 16th of May are taken from a letter dated $\frac{16}{17}$ May, 1861, to Mr. Carrington. The name *Panopea* was selected by Mr. Main.

Since the above was in type, the following communication has been received from Mr. Pogson:—

Discovery of a New Planet, "Asia."

This planet was found, like each of my previous ones, by means of my own manuscript charts; not by mere gleaning in the celestial fields prepared by other astronomers; a circumstance which enables me to assume with reasonable probability that I shall not have been preceded elsewhere. As it is the first discovery yet made in this quarter of the world, I have selected the name "*Asia*," who, as one of the Oceanides, has, I conceive, as good a right to a place in the heavens as *Europa*, *Doris*, or several others of her sisterhood. The planet is between the 11th and 12th magnitudes.

The following observations have been taken by the Boguslawski method, using only one thick bar and two comparison stars, there being no dark field micrometer attached to the telescope. I believe them to be fully equal to any I could have made of so faint an object, had the most refined instrumental means been at hand.

1861.	Madras M.T.			App. R.A.			App. N.P.D.			Log. of Par. x Δ.		Comp. Stars.
										R.A.	N.P.D.	
	h	m	s	h	m	s	h	m	s			
April 17	12	53	40	15	51	14.76	...	...	...	-9.265	...	bc
17	14	7	37	15	51	13.56	106	6	22.9	+6.704	-0.620	bc
18	11	50	39	15	50	50.72	106	1	12.7	-9.501	-0.578	bc
19	13	49	27	15	50	20.72	105	55	7.0	-8.368	-0.617	bc
20	11	46	44	15	49	53.93	105	49	50.1	-9.686	-0.579	bc
20	13	20	12	15	49	51.84	105	49	26.6	-8.934	-0.614	bc
21	11	59	5	15	49	22.97	105	43	55.3	-9.431	-0.587	ab

The second observation, on April 20, was taken and reduced by my fourth native assistant, Raganootha Chary, who readily comprehends and most willingly executes whatever I may recommend to his notice.

The adopted mean places of the comparison stars were these:—

		Mean R.A. 1861.			Mean N.P.D. 1861.		
		h	m	s	h	m	s
a	A.Z. 297.58 = 28997 Lalande	15	49	13.23	105	37	30.4
b	A.Z. 205.62	15	51	20.78	105	49	11.5
c	2026 Mädler's Bradley	15	52	31.93	106	7	14.7

The right ascension of 28997, being 6 seconds of time too great, was rejected, and Argelander's alone employed.

Madras Observatory, April 27, 1861.

The announcement, in the last Annual Report of the Council, of the death of Sir W. Dennison (p. 98), was erroneous. The Astronomer Royal has received a letter from him, dated April 8, then alive and well, and governing at Madras.

ERRATA.

Page 173, line 5 from top, *for* Lieut. Cuspendale, *read* Lieut. Carpendale.
 — 178, — 20 — *for* L. H. Casella, *read* L. P. Casella.

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MONTHLY NOTICES
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June 14, 1861.

No. 8.

Dr. LEE, President, in the Chair.

Wm. J. Rideout, Esq., Standish, near Wigan ;
S. H. Winter, Esq., Trueby House, Woodford ;
J. G. Perry, Esq., F.R.C.S. ;
Wm. Penn, Esq., Stone, near Aylesbury ; and
J. H. Dallmeyer, Esq., 19 Bloomsbury Street,

were balloted for and duly elected Fellows of the Society.

On the Secular Acceleration of the Moon's Mean Motion.
By W. F. Donkin, Esq., M.A., F.R.S., F.R.A.S., Savilian
Professor of Astronomy in the University of Oxford.

The controversy respecting the Moon's acceleration is one upon which no mathematician, professionally connected with Astronomy, could be content to accept without examination the conclusions of others. For my own satisfaction, therefore, I undertook the following investigation of the coefficient of m^4 , the calculation of which involves the whole mathematical question. For this purpose I have used the method of the variation of elements, which has already been applied by M. Delaunay ; but as I have not had an opportunity of seeing what he has published on the subject, my own result is quite independent. It will be seen that the value which I obtain for the term in question agrees with that given by Professor Adams, the correctness of which no longer admits, in my mind, of any question. The process is quite elementary, and every step may be verified by any one who is moderately familiar

with the principles of Physical Astronomy. The latest publication which has reached me on the subject is that of M. de Pontécoulant, in the *Monthly Notices*, vol. xx. No. 9. The error of his calculation admits of being very briefly stated: it consists simply in the transposition of the symbols δ and d' in the first term of the formula (c), p. 355. If the original derivation of the formula be referred to, it will be seen at once that $\int \delta d' R$ ought to be written instead of $\int d' \delta R$. The effect of the transposition is, that all the non-periodic terms which exist in $\delta d' R$ are lost. These terms are produced by integration, *when e' is treated as variable*, in forming the expression $\delta d' R$; but no such terms can arise in $d' \delta R$. If e' were treated as constant, the transposition of symbols would be immaterial. Thus we are brought back to the question whether e' is to be treated as constant or variable in integration. If any one persist in maintaining the former proposition, I do not think his opinion is likely to be affected by argument.

Neglecting the inclination, I denote by a, ι, e, ϖ , the variable elements of the Moon's orbit, viz. the major semiaxis, the mean longitude of the epoch, the excentricity, and longitude of perigee, of the instantaneous ellipse. The sum of the masses of the Earth and Moon being put = 1, n is defined by the equation $n^2 a^3 = 1$. The Moon's mean longitude is denoted by l , and defined by the equation $l = \int n dt + \iota$; so that, in forming the term $\frac{dR}{da}$ in the value of $\frac{d\delta}{dt}$, the differentiation is not to affect n as contained in l . Accented letters refer to the Sun, and the elements of the Sun's orbit are supposed to be given functions of t .

It is convenient to choose n, ι, e, ϖ , as the four variables to be determined as functions of t . Then, since $\frac{dn}{dt} = -\frac{3}{2} a^{-\frac{5}{2}} \frac{da}{dt}$, we have, by the usual formulæ, neglecting e^2 ,

$$\begin{aligned} \frac{dn}{dt} &= -\frac{3}{2} a^{-\frac{5}{2}} \frac{da}{dt}, & \frac{d\iota}{dt} &= -2na^2 \frac{dR}{da} + \frac{1}{2} nae \frac{dR}{de}, \\ e \frac{de}{dt} &= -na \frac{dR}{d\varpi}, & e \frac{d\varpi}{dt} &= na \frac{dR}{de}. \end{aligned}$$

If the disturbing function R be multiplied by a constant k , the value of which is finally to be put = 1, we may suppose the integral equations of this system to be developed in series proceeding by powers of k , of the form

$$\begin{aligned} n &= n + k\delta_1 n + k^2\delta_2 n + \dots, & \iota &= \iota_0 + k\delta_1 \iota + \dots, \\ e &= e + k\delta_1 e + \dots, & \varpi &= \varpi_0 + k\delta_1 \varpi + \dots, \end{aligned}$$

in which n, t_0, e, ϖ_∞ are four arbitrary constants independent of h , and $\delta_1 n, \delta_2 n$, &c. are the parts of the variable elements due to the first, second, &c. powers of the disturbing force, and containing in general both periodic and non-periodic terms.

The Sun's mean motion being n' , which may be considered as constant, I put $\frac{n'}{n} = m$, so that m is a constant.

The *observed mean motion* of the Moon is the non-periodic part of $\frac{dl}{dt}$, that is, of $n + \frac{dl}{dt}$: denoting this by N , I put $\frac{n'}{N} = m$, so that m is variable because N is variable.

I denote by l the value of l corresponding to $h = 0$, that is $l = nt + s_0$; so that, putting $h = 1$, we may write

$$l = 1 + \delta_1 l + \delta_2 l + \dots, \quad N = n + \delta_1 \cdot \frac{dl}{dt} + \delta_2 \cdot \frac{dl}{dt} + \dots$$

in the last of which formulæ we are only to take the non-periodic parts of $\delta_1 \cdot \frac{dl}{dt}$, &c.

It must be observed that the periodic terms which are integrated in the first approximation have, in general, arguments of the form $(i + m i') nt + \dots$. But for the purpose of finding the non-periodic part of $n + \frac{dl}{dt}$ as far as $m^4 e'^2$, the denominator introduced by integration may be always taken to be $i n$, since the retention of the complete denominator would only introduce m^5 , &c.

Putting $l - l' = \xi$, $l - \varpi = \phi$, $l' - \varpi' = \phi'$, we have, so far as is required for the present purpose,

$$\begin{aligned} R = n'^2 a^2 & \left\{ \frac{1}{4} + \frac{3}{8} e'^2 + \left(\frac{3}{4} - \frac{15}{8} e'^2 \right) \cos 2\xi \right. \\ & - \left(\frac{1}{2} + \frac{3}{4} e'^2 \right) e \cos \phi + \left(\frac{3}{4} - \frac{15}{8} e'^2 \right) e \cos (2\xi + \phi) - \left(\frac{9}{4} - \frac{45}{8} e'^2 \right) e \cos (2\xi - \phi) \\ & - \frac{3}{8} e' \cos (2\xi + \phi') + \frac{21}{8} e' \cos (2\xi - \phi') \\ & - \frac{3}{4} e e' \cos (\phi - \phi') + \frac{21}{8} e e' \cos (2\xi + \phi - \phi') + \frac{9}{8} e e' \cos (2\xi - \phi + \phi') \\ & \left. - \frac{3}{4} e e' \cos (\phi + \phi') - \frac{3}{8} e e' \cos (2\xi + \phi + \phi') - \frac{63}{8} e e' \cos (2\xi - \phi - \phi') \right\}. \end{aligned}$$

This expression comprises all terms of the first and second

orders in the excentricities, not multiplied by powers of $\frac{a}{c}$, except one term involving $e' \cos \phi'$, and terms multiplied by e^3 or e'^3 , which would be useless. The only terms required of the third order are those multiplied by $e e'^2$ with the same arguments as those of the first order multiplied by e . There can be no question about the correctness of the coefficients, which agree with those of M. de Pontécoulant (*Théorie Analytique*, t. iv. p. 58). I have, however, verified them all independently.

Putting $k=0$, we should have $n=n$, $i=i_0$, $e=e$, $\varpi=\varpi_0$; and these values are to be substituted in the differential equations for the next approximation. Taking, first, the non-periodic part of R , we thus obtain (putting $k=1$),

$$\frac{dn}{dt} = 0, \quad \frac{de}{dt} = 0, \quad \frac{d\varpi}{dt} = 0, \quad \frac{di}{dt} = \frac{n'^2}{n} \left(-1 - \frac{3}{2} e'^2 \right);$$

whence

$$n = n, \quad e = e, \quad \varpi = \varpi_0, \quad \frac{di}{dt} = -m^2 n \left(1 + \frac{3}{2} e'^2 \right),$$

and

$$N = n \left(1 - m^2 - \frac{3}{2} m^2 e'^2 \right) \dots \dots \dots (\Delta).$$

These are the only non-periodic terms depending on the first power of the disturbing force, and not involving e^3 , &c., or e'^4 , &c.

In the periodic part of R , it is convenient to take separately those terms which involve e , and those which do not. The latter are of the form

$$n'^2 a^2 p \cos (2l + \psi),$$

where p contains e' or e'^2 , and ψ is independent of quantities referring to the Moon. The differential equations obtained from this term give

$$\left. \begin{aligned} \frac{di}{dt} &= -4 \frac{n'^2}{n} p \cos (2l + \psi), \\ \frac{dn}{dt} &= 6 n'^2 p \sin (2l + \psi), \end{aligned} \right\} \dots \dots \dots (1).$$

and, introducing in their right-hand members the values corresponding to $k=0$, we have for a first approximation,

$$\frac{di}{dt} = -4 m^2 n p \cos (2l + \psi), \quad \frac{dn}{dt} = 6 m^2 n^2 p \sin (2l + \psi).$$

In integrating these we are to consider p as variable, because it contains e' ; but since $\frac{d e'}{d t}$ and $\frac{d \cdot e'^2}{d t}$ may be regarded as constant, we may treat $\frac{d p}{d t}$ as constant also. Hence, integrating by parts, we obtain $s = s_0 + \delta_1 s$, $n = n + \delta_1 n$, where

$$\delta_1 s = -2 m^2 p \sin (2 l + \psi) - \frac{m^2}{n} \frac{d p}{d t} \cos (2 l + \psi),$$

$$\delta_1 n = -3 m^2 n p \cos (2 l + \psi) + \frac{3}{2} m^2 \frac{d p}{d t} \sin (2 l + \psi);$$

From the latter expression we have, integrating again by parts,*

$$\int \delta_1 n \cdot d t = -\frac{3}{2} m^2 p \sin (2 l + \psi) - \frac{3}{2} \frac{m^2}{n} \frac{d p}{d t} \cos (2 l + \psi);$$

whence, observing that $l = l + \delta_1 l + \int \delta_1 n \cdot d t$, we have

$$\delta_1 l = -\frac{7}{2} m^2 p \sin (2 l + \psi) - \frac{5}{2} \frac{m^2}{n} \frac{d p}{d t} \cos (2 l + \psi).$$

For the next approximation we are to resume the equations (1), putting in their right-hand members $n + \delta_1 n$, $l + \delta_1 l$, instead of n , l ; hence, observing that $\frac{1}{n} = \frac{1}{n} - \frac{1}{n^2} \delta_1 n$, &c., and, taking only the non-periodic parts of the result, we obtain

$$\frac{d s}{d t} = -20 m^4 n p^2, \quad \frac{d n}{d t} = -15 m^4 n p \frac{d p}{d t};$$

the latter equation gives, by integration, $\delta_2 n = -\frac{15}{2} m^4 n p^2$; hence, so far as this term in R is concerned, the non-periodic part of $\frac{d l}{d t}$, or of $n + \frac{d s}{d t}$, is $-\frac{55}{2} m^4 n p^2$.

If p be of the form $\alpha + \beta e'^2$, this gives (neglecting e'^4),

$$\delta_2 \cdot \frac{d l}{d t} = -55 m^4 n \alpha \beta e'^2;$$

* The constant, which in strictness ought to be added, would not affect the result.

but if p be of the form $\alpha e'$, then

$$\lambda_1 \cdot \frac{dl}{dt} = -\frac{55}{2} m^4 n \alpha^2 e'^2.$$

There is one term in R of the former kind, in which $\alpha = \frac{3}{4}$, $\beta = -\frac{15}{8}$; and two terms of the latter kind, in which $\alpha = -\frac{3}{8}$, and $\alpha = \frac{21}{8}$ respectively; hence the part of N arising from these terms is

$$55 \left(\frac{45}{32} - \frac{9}{128} - \frac{441}{128} \right) m^4 n e'^2 = -\frac{7425}{64} m^4 n e'^2 \quad \dots (B)$$

The remaining terms of R are of the form

$$\pi^2 \alpha^2 p e \cos (il + j\omega + \psi),$$

where p contains e' . The differential equations now become

$$\frac{dn}{dt} = 3 i \pi^2 p e \sin (il + j\omega + \psi),$$

$$\frac{d\alpha}{dt} = -\frac{7}{2} \frac{\pi^2}{n} p e \cos (il + j\omega + \psi),$$

$$\frac{de}{dt} = j \frac{\pi^2}{n} p \sin (il + j\omega + \psi),$$

$$\frac{d\omega}{dt} = \frac{\pi^2 p}{n e} \cos (il + j\omega + \psi).$$

Proceeding in the same way as before, we obtain from the last two equations

$$\lambda_1 e = -\frac{j}{i} m^2 p \cos (il + j\omega_0 + \psi) + \frac{j}{i^2} \frac{m^2}{n} \frac{dp}{dt} \sin (il + j\omega_0 + \psi)$$

$$\lambda_1 \omega = \frac{1}{i} \frac{m^2 p}{e} \sin (il + j\omega_0 + \psi) + \frac{1}{i^2} \frac{m^2}{n e} \frac{dp}{dt} \cos (il + j\omega_0 + \psi);$$

and putting $e + \lambda_1 e$, $\omega_0 + \lambda_1 \omega$, for e , ω , in the first two, and observing that $\lambda_1 l$ and $\lambda_1 n$ would only give terms multiplied by e^2 , so that we may put l for l and n for n , we find for the non-periodic parts

$$\frac{dn}{dt} = 3 \frac{j}{i} m^4 n p \frac{dp}{dt}, \quad \frac{d\omega}{dt} = \frac{7}{2} \frac{j}{i} m^4 n p^2;$$

hence $\lambda_1 n = \frac{3}{2} \frac{j}{i} m^4 n p^2$, and the non-periodic part of $\frac{dl}{dt}$ is $5 \frac{j}{i} m^4 n p^2$. Hence, if p be of the form $\alpha + \beta e^2$, we have

$$\lambda_1 \cdot \frac{dl}{dt} = 10 \frac{j}{i} m^4 n \alpha \beta e^2;$$

but, if p be of the form $\alpha e'$, then

$$\lambda_1 \cdot \frac{dl}{dt} = 5 \frac{j}{i} m^4 n \alpha^2 e'^2.$$

There are three terms in R of the former kind, in which

$$\begin{aligned} \alpha &= -\frac{1}{2}, & \beta &= -\frac{3}{4}, & i &= 1, & j &= -1, \\ \alpha &= \frac{3}{4}, & \beta &= -\frac{15}{8}, & i &= 3, & j &= -1, \\ \alpha &= -\frac{9}{4}, & \beta &= \frac{45}{8}, & i &= 1, & j &= 1; \end{aligned}$$

and the part of N , arising from these terms, is therefore,

$$10 \left(-\frac{3}{8} + \frac{15}{32} - \frac{405}{32} \right) m^4 n e^2 = -\frac{8040}{64} m^4 n e^2 \dots (C)$$

There are six terms of the latter kind, in which

$$\begin{aligned} \alpha &= -\frac{3}{4}, & i &= 1, & j &= -1; & \alpha &= \frac{21}{8}, & i &= 3, & j &= -1; \\ \alpha &= \frac{9}{8}, & i &= 1, & j &= 1; & \alpha &= -\frac{3}{4}, & i &= 1, & j &= -1; \\ \alpha &= -\frac{3}{8}, & i &= 3, & j &= -1; & \alpha &= -\frac{63}{8}, & i &= 1, & j &= 1; \end{aligned}$$

and the part of N , arising from these, is therefore

$$\begin{aligned} 5 \left(-\frac{9}{16} - \frac{147}{64} + \frac{81}{64} - \frac{9}{16} - \frac{3}{64} + \frac{3969}{64} \right) m^4 n e^2 \\ = \frac{19140}{64} m^4 n e^2 \dots (D) \end{aligned}$$

Adding the four terms (A), (B), (C), (D), we have finally

$$N = n \left(1 - m^2 - \frac{3}{2} m^2 e^2 + \frac{3675}{64} m^4 e^2 \right);$$

but this expression has still to be transformed into one, involving m (or $\frac{n'}{N}$) instead of m (or $\frac{n'}{n}$).

Let N_0, e'_0 be the values of N, e' , when $t = t_0$, then (since m is independent of e'),

$$N - N_0 = n \left(-\frac{3}{2} m^2 + \frac{3675}{64} m^4 \right) (e'^2 - e'_0{}^2);$$

also

$$\frac{1}{N} = \frac{1}{n} (1 + m^2 + \dots);$$

hence, as far as the present approximation,

$$\frac{N - N_0}{N} = \left(-\frac{3}{2} m^2 + \frac{3579}{64} m^4 \right) (e'^2 - e'_0{}^2);$$

also, since $\frac{n'}{N} = m$, we have

$$m = m (1 + m^2 + \dots),$$

and

$$m = m (1 - m^2 + \dots);$$

whence

$$-\frac{3}{2} m^2 = -\frac{3}{2} m^2 + 3 m^4 + \dots, \text{ and } m^4 = m^4 + \dots;$$

introducing these values, we obtain

$$N - N_0 = N \left(-\frac{3}{2} m^2 + \frac{3771}{64} m^4 \right) (e'^2 - e'_0{}^2),$$

which agrees with the conclusion of Professor Adams.

It should be observed that the notation here used is not the same as that of M. de Pontécoulant, who uses n to denote what I have represented by N , namely, the mean motion of the Moon given by observation.

[With reference to M. de Pontécoulant's calculations, it may be remarked, in addition to what was said at the beginning of this paper, that the second term in his formula (c) is not in its original form, but is obtained by writing $\frac{1}{2} \left(\int d' R \right)^2$ instead of $\int (d' R \int d' R)$. The latter form would give no non-periodic term if e' were to be treated as constant; and the non-periodic terms given by the transformation would be, on that supposition, nothing better than an arbitrary function of e' , introduced as a constant in the integration. The transformation is, in fact, legitimate; but it is only so because e' is variable; and the non-periodic terms which it produces are precisely what would be obtained by applying the process of integration by parts in developing the form $d' R \int d' R$.]

Madeira, 27th May, 1861.

A communication has been received from M. de Pontécoulant, containing observations on M. Hansen's letter of the 2d Feb. 1861, to the Astronomer Royal, published in the March number of the *Monthly Notices*. M. de Pontécoulant remarks that in the lunar theory an *empirical* equation is one which is not founded on the rigorous principles of the law of gravitation, but is only introduced to make the results of calculation accordant with the observations; he is therefore surprised to see M. Hansen reckon in the class the motions of the perigee and node of the Moon's orbit, the determination of which motions is an obligatory condition of the theory. He thinks that M. Hansen has misapprehended the objection to Prof. Adams' method for the determination of the acceleration; and after remarking that it is at least presumable that there is no error or omission of terms in the calculations of Prof. Adams, confirmed as they are by the investigations of MM. Plana, Delaunay, and Lubbock, he continues as follows: "Si l'on veut donc regarder comme variable l'excentricité de l'orbite terrestre dans les équations du mouvement troublé de la Lune, ce qui paraît en effet plus exact que de traiter cette excentricité comme une quantité constante, ainsi qu'on l'avait fait jusqu'à présent, et ce qui avait paru suffisant pour la comparaison des plus anciennes observations qui nous soient parvenues, il faudrait alors substituer dans les équations différentielles du mouvement troublé de la Lune à la place de e' , qui représente l'excentricité de l'orbite terrestre, sa valeur exprimée en série de *sinus* et de *cosinus* d'arcs proportionnels à la longitude vraie de la Lune si l'on se sert des formules de Laplace, et proportionnels à sa longitude moyenne si l'on fait usage des formules ordinairement employées dans la théorie des planètes, de même que l'on substitue dans ces équations les valeurs des autres co-ordonnées du Soleil développées de la même manière avant d'opérer leur intégration. On arrivera ainsi à une exacte évaluation de l'équation séculaire, qui ne différera que très légèrement de celle que les géomètres ont obtenues en négligeant dans une première approximation les variations des éléments de l'orbite solaire, et qui représenteront les plus anciennes observations dans les limites d'exactitude que comporte l'imperfection de ces observations et le long intervalle de temps qui nous en sépare. De toute autre manière on n'obtiendra que des résultats fautifs, &c."

As to the concluding part of M. Hansen's letter, M. de Pontécoulant remarks that the conditions under which M. Hansen will approve of the only method able to give a literal and analytical solution of the problem of perturbations, on a par with the perfection of the other parts of Celestial Mechanics, are conditions which it is impossible to comply with in a question so complicated and full of difficulties—and that M. Hansen's terms amount to a refusal to accept in the lunar theory any other solution than that by mechanical substitutions.

But M. de Pontécoulant asks if the convergence of the series needs to be established *à priori*; or whether it is not sufficiently proved by the results afforded by the series themselves, calculated to an extent which shows that no appreciable quantities are neglected; and by the accordance of the values of the coefficients as obtained by the series, and as laboriously deduced from many thousands of observations. And more than this, he appeals to M. Hansen himself, who has shown in the *Astronomische Nachrichten*, vol. xvii. p. 302, by reducing Damoiseau's expression for the mean longitude to the form made use of in M. Hansen's Tables, that there is a close agreement of the two expressions—while, on the other hand, M. de Pontécoulant in his Lunar Theory has shown that the coefficients obtained by the method of series accord with those of Damoiseau—and this comparison with the same mean term shows that the results obtained by M. Hansen are the reproduction in a different form of those given by the analytical method. M. de Pontécoulant states, also, that he has recently occupied himself with the converse question of the deduction of the expression for the true longitude from M. Hansen's expression of the disturbed mean anomaly, and that with two exceptions, which he reserves for further examination, he finds that the results entirely agree with those given by his own theory.

Observations of the Variable Star α Argus.

By Francis Abbott, Esq.

Passing by Sir John Herschel's observation on this very remarkable star in the year 1837, and when it attained its maximum in January 1838; also passing over the observations made by Sir Thomas Maclear at the Cape of Good Hope, and Mackay at Calcutta, in the year 1843, when α Argus surpassed *Canopus*, and nearly equalled *Sirius*, and preserved that brilliancy till the year 1850, when Lieut. Gillis, writing from Santiago, February 1850, describes it of a reddish yellow colour, darker than *Mars*, and nearly equal in brightness to *Canopus*; from these dates I give the following observations from my own journal:—

1856. In the early part of this year I compared α Argus with the united light of the two components of α Centauri, which it nearly equalled.

1858, Feb. 10th, a gradual diminution has taken place in the brightness of this star; it now only approximates to β Crucis; if any thing, rather inferior.

1858, March 6th, η *Argus* is comparable only to γ *Crucis*, the latter being of somewhat deeper colour and more sharply defined; the former dull and hazy.

1858, April 2d, to all appearance η *Argus* and γ *Crucis* are near alike both in size and colour.

1858, May 28th, η *Argus* gradually declining, γ *Crucis* being much the brighter of the two.

1858, Oct. 8th, γ *Crucis* decidedly very superior in splendour to η *Argus*.

1859, March 27th, ϵ *Argus* is now more sharply defined than η *Argus*, it being the nearest comparison star.

1859, July 6th, η and ϵ *Argus* are now about equal; the latter is estimated at 3d mag. = 3.35 of Herschel.

1860, Nov. 2d, δ *Crucis* is scarcely equal to η *Argus*; if anything more sharply defined; the latter looking sickly, as if dying out.

1861, March 21st, δ *Crucis* is certainly very superior to η *Argus*, being much more readily found in the fading twilight.

1861, April 8th, at this date η *Argus* has not more light than ϵ *Crucis*, the former having a faint milky appearance.

1861, April 13th, ϵ *Crucis* seen in the evening twilight 10 minutes before η *Argus*.

Private Observatory, Hobart Town.

On the Probable Identification of Anthelm's Variable of 1670 (Nova Vulpeculæ), and on some other Variable Stars.
By J. R. Hind, Esq.

Early in the year 1852, I worked up the position of the star discovered by Anthelm in June, 1670, near the head of *Cygnus*, from the observations at p. 45 of Lémonnier's *Histoire Céleste*, which are probably the best that were made upon that object. The resulting place for 1850 is,

R.A. $19^{\text{h}} 41^{\text{m}} 26^{\text{s}}.8$

N.P.D. $63^{\circ} 3' 24''$.

On the 24th of April, 1852, I found close upon this point a star of 10-11 magnitude, preceding Lalande 37730 by 25 seconds in R.A. and $23^{\circ}.1$ south of it. Anthelm's star should precede about 27 seconds, with $23^{\circ}.3$ greater N.P.D., thus presenting a close agreement. I had intended to keep a watch upon this star, but, my attention being then chiefly directed to planet-hunting, I neglected to do so.

On the 24th of May in the present year, I was surprised to find the star had diminished to the 12th magnitude; and this circumstance, taken in connexion with the near accordance in

Observatory of Paris with much surprise. It could not be brought into use at present, at any rate, without continual reference to a table in which the proper names now employed would be the argument, and the ordinal number and discoverer's name, together, the equation. No person, I imagine, depending upon his memory alone, could ensure the connexion of the right name with the right number: there would be continual mistakes, and we should be exposed to waste of time and trouble in deciding to what planet reference was intended to be made. Further, the true ordinal number for a planet may be in doubt for weeks or months, as the history of the discovery of these bodies has proved in several cases. Dr. Luther's last planet, *Leto*, has been repeatedly called ⑦ in the *Bulletins* and *Astronomische Nachrichten*, but Mr. Pogson's *Asia* is really ⑥; and the intelligence of his discovery of course upset the numbers which had been adopted in Europe. Instances of this kind are pretty sure to occur again.

I might trace the effects of the introduction of the proposed system further, but the two objections here advanced appear so strong and unavoidable that it may be unnecessary to dilate upon the subject. I must give a decided vote against a change which I believe, if effected, for a time would lead to confusion and useless trouble—ultimately causing a return, by general consent, to our present nomenclature.

It has been long understood amongst astronomers that names for the small planets shall be selected from those of classical antiquity. The advantage of adhering to this neutral foundation is clear enough, and I think it is to be regretted that in two or three cases an inclination to depart from it has been evinced. *Angelina* and *Maximiliana* ought, in my opinion, to be rejected, as inconsistent with the strict interpretation of the rule; or, if allowed, it should be on the understanding that no future infractions of that rule will be tolerated. This once acknowledged, a little care in the choice of names, euphonious and not liable to be confounded with others either in writing or pronunciation, would obviate the necessity of further discussion.

The view which I have taken is equally adopted by M. Goldschmidt, to whom we owe fourteen of these planets, and by Dr. Luther, who has discovered eleven. I may perhaps be allowed to add, without entering into particulars, that the Astronomer Royal and Sir John Herschel are as strongly opposed to the suggested innovation, and also our distinguished Associate, Professor Argelander.

There is one name, unobjectionable upon other grounds, which was proposed in America for Mr. Ferguson's last planet, but which had been previously appropriated by Sir John Herschel for the interior one of the two bright satellites of *Uranus*: I allude to *Titania*. Mr. Lassell has constantly used

this name in his published observations of this satellite, as may be seen from No. 813 of the *Astronomische Nachrichten*, and various numbers of the *Monthly Notices*. As it was probably selected for the planet by inadvertence, I will venture to express a hope that Mr. Ferguson will see the propriety of substituting another. *Pseudo-Daphne*, when recovered, will require a name, and ☉ also, if our present system is to be continued; and I can neither directly nor indirectly favour its rejection.

Note on the Disposition of the Penumbra of a Solar Spot.

By W. R. Birt, Esq.

A spot that has recently entered on the Sun's disk has exhibited, in connexion with the phenomenon first observed and described by Dr. Wilson in 1769, an interesting disposition of the penumbra *on the side nearest the Sun's limb*, of such a character as to manifest, in the course of twenty-four hours, a distribution precisely the opposite of that described by the Doctor, in so far as the gradual appearance of the penumbra on the side furthest from the limb is concerned, that generally exhibiting, as observed by the Doctor, the smallest extent of penumbra.

1861, June 12^d 22^h 0^m G.M.T. A large spot with a well-defined nucleus had lately entered on the disk; the sides nearest and furthest from the limb were both destitute of penumbrae. A narrow strip of penumbra was seen between the nucleus and the limb. The margin of the nucleus furthest from the limb was sharp and well-defined.

1861, June 13^d 5^h 45^m G.M.T. A narrow fringe of penumbra on the side *furthest* from the limb; the luminous material of the photosphere *joining the margin* of the nucleus *nearest* the limb, the separate strip of penumbra between the nucleus having increased in size.

1861, June 13^d 22^h 0^m. The fringe of penumbra on the side furthest from the limb increased in breadth, and wider than the penumbra nearest the limb, excepting the separate strip which has now a few small spots. The surface of the photosphere runs in between this strip and the main spot.

The spot now visible is an interesting instance of the combination of the gradual revelation of the penumbra hidden, according to Dr. Wilson, by the curvature of the solar globe with the disturbing effect of smaller spots in the neighbourhood of larger ones, of which he has given five instances. It would appear, from the sketches I made of the spot at its three

stages, that the force producing it acted from the eastward, considerably below the photosphere, in an *oblique* direction, and that the strip of penumbra, with its included small spots, resulted from this disturbing action, and not that the spots were the agents in depriving the nucleus of its penumbra, as suggested by Dr. Wilson.

On the Ring of Saturn. By W. Lassell, Esq.

The *Monthly Notice* for April contains an interesting observation of Mr. De La Rue of the shadow of the ring of *Saturn* crossing the ball. I have lately noticed the same thing, and it is remarkable that when the ring was nearly in the same position, on the 3d of August, 1849, it was so strikingly apparent that I made a drawing of the planet, of which I send an exact tracing, and entered the following remarks in my astronomical journal.

"The peculiar feature of this unequalled view was that the most minute, but extremely black shadow of the ring upon the ball was evidently *knotted or notched, conveying the idea of mountains upon the plane of the ring, intercepting portions of the thin line of shadow, and almost breaking it up into a line of dots.*"

[The underlining is in the original].

I do not find that I have published the observation before, possibly on account of its having been made in the middle of the recess of the Society, but I have slightly alluded to the appearance, *Monthly Notices*, vol. xi. page 19, in speaking of the "serrated" form of the shadow of the ring upon the ball.

As the position of *Saturn* at the respective times was almost exactly the same in respect of the proportion of the axes, and also the superior altitude of the Earth to that of the Sun above the plane of the ring, making the portion of shadow seen very nearly equal in both observations; they are strikingly confirmatory of each other, and indicate a real peculiarity of conformation of the ring.

*Bradstones, Sandfield Park, near Liverpool,
22d May, 1861.*

On the Ring of Saturn and on Jupiter's Satellites.

By Capt. W. S. Jacob.

I have several times lately observed something of the same appearance in *Saturn* as that referred to by Mr. De La Rue, in the April Number, p. 177, especially on the 19th May, a drawing of which I send. My first impression was, that the outline of the shadow was decidedly irregular, though to a less extent than is shown in Mr. De La Rue's drawing; but, on more careful scrutiny, and when the definition was at the best, I was inclined to think that the phenomenon might possibly be an illusion, arising from a variation in the shade or tone of the shadow, by which the darker portions appeared to project beyond the rest; the power of the instrument and the state of atmospheric definition were, however, insufficient to allow of my satisfying myself thoroughly on this point. The instrument used was the very excellent 5-foot by Tully, known as the Smythian, of which I have the loan from Dr. Lee.

Jupiter's Satellites.

There have been occurring of late several eclipses or occultations of *Jupiter's* Satellites by each other; a rather curious and interesting phenomenon, though of little practical utility.

I observed one of I. by III. on April 12th, which appeared almost exactly central.

	^h	^m	^s	
First contact at	7	31	0	Greenwich M.T.
Central conjunction about	7	44		

Clouds prevented the observation of the last contact.

Also, on 19th May, an occultation of II. by I. not quite central, yet so nearly so, that at the time of conjunction the combined figure appeared to be round.

	^h	^m	^s
First contact	8	56	0
Last contact	9	4	22

At 8^h 58^m 10^s the axis of the oval formed by the combined bodies seemed to point at *Jupiter's* upper or S. Limb, and at 9^h 2^m 40^s at the N. Limb.

The power employed was 180.

Hartwell, 2d June, 1861.

*Note on an Appearance observed on Jupiter, by Mr. Birt,
March 22, 1861.* By J. Baxendell, Esq.

The appearance on *Jupiter* described by Mr. Birt at page 176 of the April number of the *Monthly Notices* was observed and sketched at Mr. Worthington's Observatory on the 17th of March last, and from observations made between that date and the 10th of April it was found that it returned to the same position on the disk of the planet in a period of $9^h 55^m 41^s \cdot 4$ mean solar time. As this agrees very nearly with the best determinations of the planet's period of rotation, we may venture to give an answer in the negative to Mr. Birt's question, "Was this an instance of a rapid propagation of cloud in the atmosphere of the planet?"

On the 10th of April a faint and narrow streak was observed lying across the bright equatorial belt in a N.P. and S.F. direction, its lower or northern end resting upon the large northern dark belt immediately above the "ragged portion," referred to by Mr. Birt, and its upper end nearly, if not quite, touching the southern dark belt. These projections upon, and sometimes quite across, a bright belt from parts of a dark belt where unusual action is going on are not of unfrequent occurrence, but do not seem to have hitherto received the attention which they appear to merit. Probably, however, this is owing to their faintness, and the difficulty of seeing them very distinctly except with telescopes of large aperture.

Manchester, May 25, 1861.

Results of Meridional Observations of Small Planets; Occultation of a Star by the Moon; and Phenomena of Jupiter's Satellites; observed at the Royal Observatory, Greenwich, during the month of May, 1861.

(Communicated by the Astronomer Royal.)

Iris (7).

Mean Solar Time of Observation.	R.A. from Observation.			N.P.D. from Observation.					
	h	m	s	h	m	s			
1861, May 4	12	29	55.4	15	21	23.15	112	40	13.69
13	11	45	39.8	15	12	29.27	111	56	7.37
14	11	40	44.5	15	11	29.70	111	50	53.23
17	11	26	0.3	15	8	32.81	111	34	54.66
18	11	21	6.3	15	7	34.54	111	29	36.16
21	11	6	27.1	15	4	42.56	111	13	16.79
24	10	51	53.8	15	1	56.60	110	56	47.09
25	10	47	4.1	15	1	2.65	110	51	23.60

Panopea (70).

Mean Solar Time of Observation.	R. A. from Observation.		N. P. D. from Observation.	
	h	m	s	°
1861, May 14	11	3	39.0	104 26 3.67

The observations of *Iris* in N.P.D. have been corrected both for refraction and parallax; that of *Panopea* has been corrected for refraction only.

Occultation of B. A. C. 4006 by the Moon.

1861, May 19. The disappearance at the Moon's dark limb was observed by Mr. Dunkin to take place at 8^h 53^m 32^s.2 Mean Solar Time.

Phenomena of Jupiter's Satellites.

Day of Observation.	Satellite.	Phenomenon.	Mean Solar Time.			Observer.
1861.			h	m	s	
May 13	I	Eclipse, reapp.	11	13	18.9	C.
17	II	Egress, bisection (<i>a</i>)	9	47	47.3	E.
25	III	Ingress, first cont.	8	24	24.2	K.
25	III	Ingress, bisection	8	26	53.8	K.
25	III	Ingress, last cont.	8	29	53.3	K.
26	II	Eclipse, reapp.	10	1	37.5	E.

(α), Unsatisfactory, the images being extremely tremulous.

The initials, E., C., and K., are those of Mr. Ellis, Mr. Criswick, and Mr. Kerschner.

Occultation of Mars by the Moon, observed at the Dudley Observatory, 1861, May 12. By O. M. Mitchel, Jun.

(Communicated by Professor O. M. Mitchel through the Astronomer Royal.)

Phenomenon.	Sidereal Time of Observation.	
	h	m
Disappearance	11	0 46.7
Last Contact	12	1 28.8

Very hazy; observations satisfactory, however.

Occultation observed at Highbury. By T. W. Burr, Esq.

1861, May 19th. The star B.A.C. 4006 disappeared instantaneously at the dark limb of the Moon at 12^h 42^m 56^s.7, local sidereal time. The reappearance was not seen. Telescope 4 ft. 4 in. refractor; 3½ inches aperture. Power 173. Longitude 24° W.

Elements of Minor Planet (66).

(Communicated by Prof. Bond.)

Mr. Hall finds the following elements for the new asteroid (66), which has received the name of *Maia*, confirmed by Hon. Josiah Quincy, the venerable ex-President of Harvard College:

Epoch, 1861, May 16^h 3574^m 8, Washington M.T.

M	139 27 11 ^h 9	} Mean Equinox, 1861 ^o .
π	43 54 5 ^h 7	
Ω	8 11 41 ^h 7	
i	3 4 8 ^h 8	
ϕ	8 52 19 ^h 5	
Log a	0 ^h 423879	
μ	820 ^h 71	

By reason of the date of the discovery by Mr. Pogson of the Minor Planet *Asia* the numbers of the last four Minor Planets are:—

- (67) *Asia*, Mr. Pogson.
- (68) *Leto*, Dr. Luther.
- (69) .. M. Schiaparelli.
- (70) *Panopea*, M. Goldschmidt.

Places of Comet I. 1861. By N. M. R. Edmondson, Assistant, Armagh Observatory.

G. M. T.	R. A.	Par. in R. A.	N. P. D.	Par. in N. P. D.
May 10 ^h 4443	8 56 21 ^m 22 + π x 0 ^h 0390	67 28 33 ^h 56 — π x 0 ^h 6656		
12 ^h 4252	8 44 47 ^m 49	0 ^h 0369	73 59 47 ^h 97	0 ^h 7155
14 ^h 4563	8 34 39 ^m 98	0 ^h 0391	79 55 40 ^h 40	0 ^h 7853
Stars.		Comparisons.	Assumed Places.	
77	Cancr	5	Armagh Catalogue.	
63	"	5	"	
36	"	4	"	

Elements and Ephemeris of Comet I. 1861. By Dr. C. F. Pape.

Elliptic Elements from April 10, May 1 and 2, and May 18.

T = June 3^h 2285^m 4 Mean Berlin Time.

π = 243 3 15 ^h 2	} Mean Equinox 1861 ^o
Ω = 29 51 9 ^h 8	
i = 79 55 3 ^h 7	
log e = 9 ^h 997335	
log q = 9 ^h 964536	
log a = 2 ^h 177951	
Period = 1848 ^h 9 years.	

Ephemeris for 0^h Mean Berlin Time, available for Mean Equinox.

	R.A.	Decl.	Log r (Sun).	Log Δ (Earth).	Bright- ness.	Rises before Sun. h
1861.						
July 21	104 23.5	34 4.8	0.09320	0.16443	0.25	3.7
23	104 1.5	34 30.8				
25	103 39.3	34 57.3	0.10861	0.17246	0.22	4.1
27	103 16.6	35 24.3				
29	102 53.4	35 52.0	0.12390	0.17922	0.20	4.4
31	102 29.5	36 20.3				
Aug. 2	102 4.8	36 49.2	0.13901	0.18479	0.18	4.7
4	101 38.9	37 18.6				
6	101 11.8	—37 48.6	0.15377	0.18927	0.17	5.0

The brightness is assumed = 1.0 on April 10, when the Comet was about 6 mag. The rising of the Comet is calculated for the latitude of the Cape Observatory.

Altona, June 4, 1861.

Observations of Comet I. 1861, made with the Olcott Meridian Circle, at the Dudley Observatory. Observed by G. W. Hough.

(Communicated by Professor O. M. Mitchel through the Astronomer Royal.)

Date.	Mean Time of Obs.	App. R.A.	App. Decl.
	^h ^m ^s	^h ^m ^s	[°] ['] ["]
April 11	15 38 38.57	17 0 45.51	+ 60 21 25.37
17	14 19 58.29	16 4 12.61	65 7 16.73
19	13 39 22.98	15 32 42.77	66 34 3.16
24	11 22 40.44	13 35 20.54	67 45 20.68
25	10 50 16.98	13 6 48.31	67 10 47.57
26	10 17 42.63	12 38 5.17	+ 66 13 3.54

The Declinations are corrected for refraction, but not parallax.

The Right Ascensions are the mean of fifteen wires, with the exception of April 17th, when only two were observed.

April 25th, Strong moonlight; Comet very difficult to observe.

Prof. Bond, in a letter dated Observatory of Harvard College, 4th June, 1861, addressed to Mr. Carrington, writes as follows:—

I notice, in the *Monthly Notices* for April, that Mr. Thatcher

communicates an observation of the Comet I., 1861, to the Astronomer Royal, as follows:—

1861, April 10, 11^h 32^m 42^s.

R.A. 17^h 7^m 42^s.76 Decl. + 59° 30' 8".

The observation intended is evidently that made at Cambridge on the 10th, appropriated, as it is printed in the *Notices*, *without* an acknowledgment, and *with* two important errors. The time is Cambridge, not New York time; and the declination should read

+ 59° 28' 12" 8.

The right ascension is more precisely

17^h 7^m 42^s.60,

as reported to you in my letter of the 25th April.

The correction is of some consequence, as the position is one of the earliest obtained of the Comet.

Capt. Shea continues with regularity, and sends to the Society, the Observations of Solar Spots which he has been engaged on for several years past.

Accounts have been received of the large Comet which has recently appeared. Mr. Burder, in a letter dated Clifton, June 30, 1861, 4 P.M., addressed to the Secretary of the Society, writes:—

"I saw a Comet at 2^h 40^m A.M. to-day,* and lost sight of it (through the approach of daylight) at 3^h 20^m A.M. It was as bright as *Capella*. It had no tail that I could see, but it had a bright nucleus surrounded by a nebulous haze.

"Its azimuth at 3^h 10^m A.M. was about 39° east of north, and its altitude about 10°, both *very rough* observations, as I had not time to apply instruments; or rather was afraid to run the risk of losing the object in the increasing daylight while preparing them. I therefore made the best of neighbouring buildings, the position of which I measured afterwards."

Mr. Stothard, in a letter dated Dublin, July 1st, 1861, writes:—

"On last evening (June 30th), about 10 o'clock P.M., Dublin time, as I was closing my instrument, after an observation of *Jupiter*, I was very much surprised at seeing a remarkable-looking nebulosity in the full glare of the twilight, in the north-west part of the heavens, which twilight was then so great as to render invisible all stars in those regions nearly as far as the zenith. I soon perceived in the object a distinct and

* Viz. on the morning of June 30.—Ed.

planetary-looking nucleus, which was well seen in an opera-glass, and shone out like the disk of a planet seen with a low power with a dense halo round it.

"This halo I found to be of a semi-lunar form, the convexity being in the direction of the Sun. I saw this well both in a large opera-glass and in my $2\frac{1}{2}$ -inch achromatic, with the lowest power I have, an erecting eye-piece of 22.

"As the twilight faded, the tail came out; but, although I watched until midnight, the night was not dark enough to show it well.

"I could not help thinking that, had it been a dark season of the year, and the Comet been higher in the sky, it would have been one of the most remarkable seen for many years, larger, and I should say (under the same circumstances) more brilliant, than that of 1858 (Donati's).

"The Comet at midnight was almost due north, and must have been in or near the constellation *Auriga*; but I could not see the stars in that neighbourhood with the unaided eye. I did see one with the $2\frac{1}{2}$ -inch refractor, a little lower, and following. Its altitude was low at 12^h.

"The suddenness of its apparition, together with its size and brilliancy, is remarkable.

"I have no doubt, from these two latter qualities, size and brilliancy, that it must have been visible for some time in these latitudes; but as yet we have heard nothing about it here."

Mr. Tidmarsh, in a letter dated Downside College, Bath, July 1st, 1861, calls attention to a splendid Comet, "which has been visible here during the night in the constellation of *Auriga*, situated at present about as far from β *Aurigæ* as that star is distant from *Capella*, and about the same north declination as *Capella*.

"The nucleus is very large and bright, and was distinctly visible to the naked eye as a Comet before half-past nine o'clock, P.M.

"It passed its lower transit at about ten minutes past midnight, and the huge tail then extended at least sixty or seventy degrees across the heavens. It could be distinctly traced across *Polaris*, and considerably beyond, nearly in the direction of *Vega*."

The following observation, made with the transit-circle at the Royal Observatory, Greenwich, by W. J. Carpenter, has also been received:—

Greenwich M.T.	App. R.A.	App. N.P.D.
1861, June 30 ^d 12 ^h 53 ^m 53 ^s .9	6 ^h 42 ^m 1 ^s .48	43° 0' 8".2.

The N.P.D. is corrected for refraction.

Daily motion in R.A.....	... + 48"	} Approximate.
" " N.P.D.....	— 8°	

ERRATA.

Page 211, line 26 from top, *for third, read first.*

- 214, — 29 — *for a point on the other, read one or the other.*
- — — 12 from bottom, *for desk, and bottom line for disk, read dish.*
- 215, lines 16, 17 from top, *for pen A and pen B, read bar A and bar B.*
- — line 19 from top, *for instantaneously, read simultaneously.*

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MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. XXI.

Supplemental Notice.

No. 9.

On the Positions of the Radcliffe Catalogue. By T. H. Safford, Assistant at the Observatory of Harvard College.

(Communicated by Prof. Bond.)

The differences given by the editor, the Rev. R. Main (*Radcliffe Catalogue*, p. v.) between the *Radcliffe* and the *Twelve-Year Catalogue*, can be approximately represented by the following formula:—

Diff. of R.A. (Green. 12-Year C.—Rad.) = $-0^{\circ}.038 + 0^{\circ}.032 \sin (a + 5^{\text{h}} 32^{\text{m}})$,

where a is the Right Ascension.

The remaining discrepancies are

R.A. (Form.—Obs.)		R.A. (Form.—Obs.)		R.A. (Form.—Obs.)	
^h	^s	^h	^s	^h	^s
0	-0'006	8	-0'004	16	-0'004
1	-0'007	9	-0'011	17	-0'016
2	+0'050	10	+0'024	18	-0'008
3	+0'024	11	+0'021	19	-0'009
4	-0'032	12	+0'030	20	+0'008
5	-0'030	13	+0'011	21	+0'005
6	-0'018	14	+0'004	22	0'000
7	-0'017	15	-0'030	23	+0'013

These remaining differences, although in some instances large, do yet change sign very frequently, and it will be observed that their mean between 10^{h} and 15^{h} is only $+0^{\circ}.010$, whereas the mean of the original discrepancies deduced by Mr. Main between the same limits was $0^{\circ}.05$ after subtracting the difference ($0^{\circ}.038$) of equinoxes.

In investigating the causes which would give rise to such systematic discrepancies, I was first struck with the fact that

the same, or nearly the same, variations were apparent in the assumed places of the time-stars, for years since 1845; that, if correct positions of time-stars had been assumed, the resulting positions would have been free from these small errors.

To prove this it is only necessary to adduce the comparisons made.

Denoting by A the positions (for Radcliffe time-stars) of the *Twelve-Year Catalogue* for 1845; by B, the assumed places for the same year (*Radcliffe Observations*, vol. vi. p. vii.) of the same stars; and by C, the results of that year's observations at the Radcliffe Observatory, we have on the average:—

Hours of E.A.	B—A.	C—B.	C—A.	No. Stars.	No. Obs.
0 to 9	+0°019	—0°002	+0°017	43	174
10 „ 15	+0°074	—0°000	+0°064	15	62
16 „ 23	+0°023	—0°001	+0°025	36	118

The weights given to the numbers in the second and third columns only, are proportional to the number of observations. The discrepancy is apparent enough, but it is nearly the same in C as B; showing that the observations of 1845 neither increased nor diminished to any sensible amount the discrepancy which already existed in the places of the time-stars. There is a slight casual non-agreement between (B—A) + (C—B) and (C—A), owing to the different weights allowed.

So far as the second column (C—B) is concerned, a similar investigation showed much the same results for every year between 1840 and 1844. The year 1840, it is true, gave a value of about +0°015 between 10^h and 15^h for C—B. This probably contributed somewhat to the variations apparent in the time-stars of the following years, but a similar amount did not again appear; but the *Nautical Almanac* places for 1840, compared with the *Twelve-Year Catalogue* places for the same year, exhibit the following differences in the mean:—

Hours.	B—A.
0 to 9	+0°077
10 „ 15	+0°093
16 „ 23	+0°083

This, so far as it is not constant, is entirely owing to the proper motions of the *Nautical Almanac* stars, which were generally neglected until 1848.

These yearly proper motions are, on the average (making that of stars for which they were taken into account in 1840 = 0):—

Hours.	°
0 to 9	+0°004
10 „ 15	+0°001
16 „ 23	+0°004

so that this error, which is contained in the Radcliffe time-stars, may have increased the variations in question.

In fact there is a tendency, in all proper motions in R.A., to be less (positively) between 10^h-15^h , or about these limits, than for other right ascensions; so that, not only the places of *Nautical-Almanac* stars, but those of other stars, will be somewhat erroneous, systematically, in this way, if computed without proper motion.

But why can errors of this kind remain, as we have seen that they do, in the results of observations? It would seem that they must be diminished by observing many stars together, and correcting their right ascensions mutually.

Suppose that N time-stars are observed in one day; that their right ascensions are $a, a + \beta, a + \beta', \&c.$, and that these stars are equally used for the clock-errors. If a discrepancy of the form

$$m + n \sin a + p \cos a$$

exist, its effect upon the clock-errors for that day will be

$$m + \frac{n \{ \sin a + \sin (a + \beta) + \sin (a + \beta') + \&c. \}}{N} \\ + p \frac{\{ \cos a + \cos (a + \beta) + \cos (a + \beta') + \&c. \}}{N};$$

or, expanding

$$m + n \sin a \frac{(1 + \cos \beta + \cos \beta' + \&c.)}{N} \\ + p \cos a \frac{(1 + \cos \beta + \cos \beta' + \&c.)}{N} \\ - p \sin a \frac{(\sin \beta + \sin \beta' + \&c.)}{N} \\ + n \cos a \frac{(\sin \beta + \sin \beta' + \&c.)}{N};$$

and this will be a resulting error in the observed place, for that night, of the star whose right ascension is a .

Let the same star be observed again, in other groups. The mean of all the quantities represented by $\sin \beta$ will be very nearly $= 0$; because every time-star will be compared with many stars on each side of it, so that many of the quantities represented by β will be positive, and many negative.

But, on the other hand, if β be always small (less than

6 hours in almost all cases), the value of its cosine will be positive, and that of $\frac{1 + \cos \beta + \cos \beta' + \&c.}{N}$ will be nearly = 1, including, as it must, many instances in which the stars compared are within an hour or two of each other.

The effect of this will be (as we have seen in the *Radcliffe Observations*) to perpetuate any small systematic discrepancy of this kind.

But systematic differences depending on the declination tend to destroy themselves, unless the form of the pivots of the transit-instrument be erroneous.

I am, however, disposed to lay most stress upon the observed fact that the results of the *Radcliffe Observations* do, so far as the discrepancy in question is concerned, agree essentially with the assumed places of time-stars.

Hence it does not seem probable that the discrepancies in question have arisen from any instrumental error or error of observation, at least to the amount which they have reached.

Mr. Auwers, of Königsberg, has given (*Astr. Nachr.*, No. 1300) the following formula for correcting the *Radcliffe declinations*, so as to make them agree with Wolfers' *Tabulae Reductionum*:—

$$\Delta \delta = -4''.27 + 0''.0647 \delta^{\circ}.$$

I have tabulated these values with changed sign, so as to make them apply to N.P.D., and placed opposite them Mr. Johnson's own corrections:—

N.P.D.	Formula, Auwers.	Mr. Johnson's Correction.
0	"	"
0	-1'.55	+0'.92
10	-0'.91	+1'.03
20	-0'.26	+1'.15
30	+0'.39	+1'.28
40	+1'.04	+1'.38
50	+1'.68	+1'.46

These differ largely, and it is perhaps doubtful whether Mr. Auwers intended his formula to apply within 30° N.P.D. On the other hand, Wolfers' investigation (*Astr. Nachr.*, No. 1181) shows a general agreement between the *Radcliffe corrected* places and his own declinations.

Ephemeris of Encke's Comet. Calculated by Prof. Encke, and
Communicated by the Astronomer Royal.

(For Berlin Mean Noon.)

	R.A.	Decl.	Log Δ.	Log r.
1851.	^h ^m ^s	[°] ['] ^{''}		
Oct. 3	0 22 35.05	+ 18 59 53.1	0.044417	0.319852
4	20 13.79	53 28.2	0.040352	0.317687
5	17 50.40	46 36.7	0.036381	0.315552
6	15 25.01	39 18.6	0.032507	0.313295
7	12 57.78	31 34.1	0.028732	0.311067
8	10 28.85	23 23.0	0.025061	0.308817
9	7 58.39	14 45.7	0.021497	0.306544
10	5 26.55	+ 18 5 42.2	0.018043	0.304249
11	2 53.53	+ 17 56 13.1	0.014701	0.301931
12	0 0 19.47	46 18.6	0.011474	0.299589
13	23 57 44.57	35 59.2	0.008365	0.297224
14	55 8.99	25 15.5	0.005375	0.294834
15	52 32.93	14 8.2	0.002507	0.292420
16	49 56.57	+ 17 2 37.8	9.999761	0.289980
17	47 20.09	+ 16 50 45.3	9.997139	0.287515
18	44 43.67	38 31.3	9.994642	0.285023
19	42 7.51	25 56.9	9.992271	0.282505
20	39 31.78	+ 16 13 3.0	9.990026	0.279960
21	36 56.67	+ 15 59 50.6	9.987906	0.277388
22	34 22.37	46 20.9	9.985913	0.274787
23	31 49.07	32 35.1	9.984045	0.272158
24	29 16.95	18 34.4	9.982301	0.269500
25	26 46.18	+ 15 4 20.1	9.980681	0.266812
26	24 16.92	+ 14 49 53.5	9.979182	0.264093
27	21 49.35	35 16.1	9.977803	0.261344
28	19 23.63	20 29.1	9.976542	0.258564
29	16 59.90	+ 14 5 34.1	9.975395	0.255571
30	14 38.31	+ 13 50 32.4	9.974361	0.252906
31	12 19.01	35 25.5	9.973435	0.250027
Nov. 1	10 2.13	20 14.8	9.972615	0.247114
2	7 47.80	+ 13 5 1.7	9.971897	0.244167
3	5 36.14	+ 12 49 47.5	9.971276	0.241184
4	3 27.24	34 33.7	9.970748	0.238164
5	23 1 21.21	19 21.7	9.970309	0.235107
6	22 59 18.11	+ 12 4 12.6	9.969955	0.232013
7	57 18.00	+ 11 49 7.7	9.969680	0.228880
8	55 20.96	34 8.0	9.969479	0.225708
9	22 53 27.05	+ 11 19 14.5	9.969341	0.222495

1861.	R. A.	Decl.	Log A.	Log r.
	^h ^m ^s	[°] ['] ^{''}		
Nov. 10	22 51 36.31	+ 11 4 28.3	9.969281	0.219240
11	49 48.79	+ 10 49 50.6	9.969273	0.215943
12	48 4.51	35 22.2	9.969320	0.212603
13	46 23.48	21 4.0	9.969415	0.209219
14	44 45.71	+ 10 6 56.8	9.969555	0.205790
15	43 11.21	+ 9 53 1.3	9.969734	0.202314
16	41 39.97	39 18.0	9.969947	0.198791
17	40 12.00	25 47.6	9.970189	0.195219
18	38 47.28	+ 9 12 30.5	9.970456	0.191598
19	37 25.80	+ 8 59 27.2	9.970743	0.187926
20	36 7.55	46 38.2	9.971044	0.184201
21	34 52.49	34 3.9	9.971355	0.180423
22	33 40.61	21 44.6	9.971672	0.176589
23	32 31.87	+ 8 9 40.6	9.971990	0.172699
24	31 26.23	+ 7 57 52.2	9.972304	0.168751
25	30 23.67	46 19.6	9.972609	0.164744
26	29 24.14	35 3.0	9.972902	0.160675
27	28 27.59	24 2.7	9.973177	0.156544
28	27 33.98	13 18.5	9.973432	0.152349
29	26 43.26	+ 7 2 50.5	9.973660	0.148088
30	25 55.37	+ 6 52 38.7	9.973857	0.143758
Dec. 1	25 10.25	42 42.9	9.974020	0.139358
2	24 27.85	33 3.0	9.974144	0.134886
3	23 48.10	23 39.0	9.974224	0.130340
4	23 10.93	14 30.7	9.974257	0.125718
5	22 36.27	+ 6 5 37.8	9.974239	0.121018
6	22 4.05	+ 5 57 0.1	9.974163	0.116236
7	21 34.18	48 37.2	9.974028	0.111371
8	21 6.59	40 28.8	9.973829	0.106419
9	20 41.19	32 34.3	9.973562	0.101379
10	20 17.89	24 53.4	9.973224	0.096247
11	19 56.61	17 25.7	9.972811	0.091020
12	19 37.25	10 10.5	9.972319	0.085696
13	19 19.73	+ 5 3 7.2	9.971744	0.080271
14	19 3.95	+ 4 56 15.2	9.971083	0.074741
15	18 49.82	49 33.8	9.970331	0.069104
16	18 37.23	43 2.4	9.969486	0.063355
17	18 26.08	36 40.2	9.968543	0.057490
18	18 16.26	30 26.3	9.967498	0.051506
19	18 7.68	24 19.9	9.966349	0.045398
20	18 0.23	18 20.1	9.965088	0.039161
21	17 53.79	12 26.2	9.963714	0.032791
22	22 17 48.23	+ 4 6 36.9	9.962223	0.026282

Ephemeris of Encke's Comet.

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	R.A.			Decl.	Log Δ.	Log r.
1861.	h	m	s	°		
Dec. 23	22	17	43.42	+ 4 0 51.1	9.960610	0.019630
24		17	39.22	+ 3 55 7.4	9.958870	0.012828
25		17	35.46	49 24.8	9.956999	0.005872
26		17	31.99	43 41.6	9.954992	9.998754
27		17	28.66	37 56.5	9.952845	9.991470
28		17	25.29	32 7.8	9.950553	9.984011
29		17	21.69	26 13.7	9.948110	9.976371
30		17	17.64	20 12.0	9.945512	9.968543
31	22	17	12.90	+ 3 14 0.1	9.942752	9.960517
1862.						
Jan. 1	22	17	7.22	7 35.8	9.939826	9.952287
2		17	0.33	+ 3 0 56.7	9.936727	9.943843
3		16	51.96	+ 2 53 59.4	9.933452	9.935177
4		16	41.73	46 40.4	9.929993	9.926279
5		16	29.28	38 55.9	9.926346	9.917138
6		16	14.25	30 42.0	9.922506	9.907744
7		15	56.23	21 54.3	9.918468	9.898088
8		15	34.72	12 27.6	9.914227	9.888158
9		15	9.19	+ 2 2 15.9	9.909780	9.877942
10		14	39.08	+ 1 51 13.1	9.905123	9.867429
11		14	3.78	1 39 12.2	9.900254	9.856605
12		13	22.60	1 26 5.3	9.895173	9.845459
13		12	34.78	1 11 43.5	9.889880	9.833982
14		11	39.45	0 55 57.0	9.884376	9.822160
15		10	35.62	0 38 34.9	9.878665	9.809979
16		9	22.25	+ 0 19 25.1	9.872759	9.797434
17		7	58.22	- 0 1 45.9	9.866673	9.784517
18		6	22.30	0 25 12.4	9.860427	9.771224
19		4	33.19	0 51 10.9	9.854045	9.757552
20		2	29.43	1 19 58.8	9.847563	9.743504
21	22	0	9.44	1 51 54.8	9.841029	9.729091
22	21	57	31.62	2 27 18.2	9.834500	9.714331
23		54	34.39	3 6 29.1	9.828055	9.699255
24		51	16.21	3 49 47.1	9.821789	9.683909
25		47	35.62	4 37 29.3	9.815818	9.668353
26		43	31.43	- 5 29 50.6	9.810283	9.652686
27		39	2.96	6 26 59.4	9.805347	9.637011
28		34	10.13	7 28 56.3	9.801202	9.621484
29		28	53.80	8 35 30.7	9.798055	9.606292
30		23	16.07	9 46 18.1	9.796119	9.591673
31		17	20.34	11 0 37.3	9.795613	9.577897
Feb. 1		11	11.67	12 17 30.1	9.796724	9.565284
2	21	4	56.87	13 35 40.9	9.799611	9.554178
3	20	58	43.64	- 14 53 45.1	9.804343	9.544931

1888. Feb.	4	R.A.			Decl.			Log Δ.	Log r.
		h	m	s	°	'	"		
	4	20	52	40.93	-16	10	11.2	9.810924	9.537878
	5		46	57.94	17	23	29.7	9.819265	9.533303
	6		41	42.87	18	32	23.6	9.829186	9.531399
	7		37	2.66	19	35	53.2	9.840441	9.532254
	8		33	2.33	20	33	18.8	9.852742	9.535827
	9		29	44.52	21	24	23.3	9.865784	9.541967
	10		27	9.75	22	9	7.3	9.879280	9.550414
	11		25	16.66	22	47	45.7	9.892977	9.560853
	12		24	2.54	23	20	43.5	9.906654	9.572933
	13		23	23.86	23	48	30.0	9.920146	9.586304
	14		23	16.54	24	11	38.1	9.933327	9.600637
	15		23	36.57	-24	30	39.9	9.946111	9.615640
	16		24	19.94		46	5.4	9.958442	9.631064
	17		25	23.08	24	58	21.8	6.970288	9.646703
	18		26	42.66	25	7	54.1	9.981637	9.662392
	19		28	15.86		15	4.0	9.992488	9.678001
	20		30	0.17	20	10.7		0.002849	9.693434
	21		31	53.51	23	30.2		0.012736	9.708618
	22		33	54.11	25	16.6		0.022169	9.723503
	23		36	0.41	25	42.5		0.031168	9.738051
	24		38	11.09	24	58.6		0.039752	9.752240
	25		40	25.09	23	14.1		0.047944	9.766056
	26		42	41.51	20	36.9		0.055766	9.779494
	27		44	59.61	17	13.7		0.063237	9.792554
	28		47	18.79	13	10.2		0.070377	9.805242
Mar.	1		49	38.49		8	31.8	0.077203	9.817560
	2		51	58.24	-25	3	23.4	0.083733	9.829517
	3		54	17.73	-24	57	48.6	0.089982	9.841123
	4		56	36.69		51	50.7	0.095968	9.852393
	5	20	58	54.85		45	33.0	0.101702	9.863337
	6	21	1	11.99		38	58.3	0.107199	9.873968
	7		3	27.93		32	8.9	0.112469	9.884298
	8		5	42.59		25	6.7	0.117525	9.894337
	9		7	55.83		17	53.6	0.122377	9.904096
	10		10	7.55		10	31.5	0.127034	9.913588
	11		12	17.69	-24	3	1.7	0.131504	9.922823
	12		14	26.20	-23	55	25.6	0.135797	9.931812
	13		16	33.03		47	44.4	0.139920	9.940566
	14		18	38.15		39	59.2	0.143880	9.949094
	15		20	41.53		32	10.9	0.147684	9.957404
	16		22	43.16		24	20.4	0.151338	9.965507
	17		24	43.04		16	28.5	0.154848	9.973410
	18		26	41.14		8	36.0	0.158219	9.981121

	R. A.			Decl.	Log Δ.	Log r.
1862.	h	m	s	°		
Mar. 19	21	28	37.48	-23 0 43.6	0.161455	9.988648
20		30	32.05	-22 52 51.8	0.164562	9.995998
21		32	24.86	45 1.3	0.167544	0.003178
22		34	15.90	37 12.6	0.170406	0.010195
23		36	5.19	29 26.2	0.173150	0.017054
24		37	52.73	21 42.6	0.175781	0.023762
25		39	38.52	14 2.2	0.178302	0.030325
26		41	22.58	-22 6 25.2	0.180717	0.036748
27		43	4.91	-21 58 52.0	0.183028	0.043035
28		44	45.51	51 23.2	0.185239	0.049192
29		46	24.39	43 59.0	0.187352	0.055223
30		48	1.57	36 39.7	0.189370	0.061133
31		49	37.06	29 25.6	0.191296	0.066926
April 1		51	10.86	22 16.8	0.193132	0.072605
2		52	42.99	15 13.7	0.194881	0.078176
3		54	13.45	8 16.5	0.196545	0.083641
4		55	42.25	-21 1 25.4	0.198125	0.089003
5		57	9.40	-20 54 40.6	0.199624	0.094266
6		58	34.92	48 2.3	0.201044	0.099434
7	21	59	58.80	41 30.6	0.202386	0.104508
8	22	1	21.07	35 5.6	0.203653	0.109493
9		2	41.73	28 47.6	0.204847	0.114391
10		4	0.79	22 36.6	0.205969	0.119204
11		5	18.25	16 32.8	0.207021	0.123935
12		6	34.12	10 36.4	0.208004	0.128587
13		7	48.42	-20 4 47.6	0.208919	0.133161
14		9	1.14	-19 59 6.4	0.209767	0.137661
15		10	12.30	53 33.0	0.210550	0.142088
16	22	11	21.89	-19 48 7.6	0.211268	0.146445

Elements.

Epoch, 1862, Feb. 6, 20 Berlin.

$L = 158^{\circ} 1' 0''$ Mean longitude.
 $M = 0^{\circ} 0' 10''$ Mean anomaly.
 $\pi = 158^{\circ} 0' 50''$ Long. of perih. } Mean Eq.
 $\Omega = 334^{\circ} 30' 50''$ Long. of node. } Feb. 6.
 $i = 13^{\circ} 5' 0''$ Inclination.
 $\phi = 57^{\circ} 57' 20''$ Angle of excentricity.
 $n = 1074''.625$ Mean diurnal motion.
 $\text{Log. } a = 0.3458331$

Ephemeris of Encke's Comet.

1898.	R.A.	Decl.	Log A.
	^h ^m ^s	[°] ['] ["]	
Feb. 4	20 52 40.93	-16 10 11.2	9.810924
5	46 57.94	17 23 29.7	9.819265
6	41 42.87	18 32 23.6	9.829186
7	37 2.66	19 35 53.2	9.8404
8	33 2.33	20 33 18.8	9.852
9	29 44.52	21 24 23.3	9.86
10	27 9.75	22 9 7.3	9.8
11	25 16.66	22 47 45.7	9.8
12	24 2.54	23 20 43.5	
13	23 23.86	23 48 30.0	
14	23 16.54	24 11 38.1	
15	23 36.57	-24 30 39.9	
16	24 19.94	46 5.1	
17	25 23.08	24 58 21.2	
18	26 42.66	25 7 8.4	
19	28 15.86	15	
20	30 0.17	20	
21	31 53.51	21	
22	33 54.11	22	
23	36 0.41	23	
24	38 11.09	24	
25	40 25.09	25	
26	42 41.51	26	
27	44 59.61	27	
28	47 18.79	28	
Mar. 1	49 38.49		
2	51 58.24		
3	54 17.73		
4	56 36.00		
5	20 58 54.00		
6	21 1 1.00		
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			

(North +)
Decl.
Comet - Star.

R.A.	Decl.
Comet - Star.	Comet - Star.
+1 21.5	*
20.6	+11 34
21.3	*
20.5	11 41
21.8	11 37
+2 9.3	+21 30
10.4	21 43
+2 28.7	-8 33
28.9	29
28.9	28
29.4	24
29.1	22

to be depended on for Declination.

Star.	R.A.	(North +)
	Comet — Star.	Decl.
	m s	m s
B.A.C. 1373	+ 3 19.1	— 6 25
	19.2	11
	19.6	5 55
	20.0	6 6

... observed four times with the meridian circle in

... tabular position requires correction + 0".3 in R.A.

... + 0".7 in N.P.D.

None of the other stars have been observed here on the meridian.

June	d	h m s	Star of 7th magnitude. Approximate R.A. 4 ^h 1 ^m 39 ^s Decl. — 27° 47' 23"	m s	m s
11	6	3 4		+ 2 29.6	+ 4 57
		7 29		29.8	5 18
		11 29		30.0	23
		15 31		29.9	22
		19 40		30.3	30
		23 37		30.4	34
		27 32		30.5	46
14	6	4 40	B.A.C. 1355	— 7 50.9	+ 9 18
		15 3		50.1	42
		25 10		48.6	59
15	6	1 2	Laetitia 1431	— 7 46.1	+ 6 33
		10 58		45.8	7 2
		20 7		44.3	7 20
		37 10		43.9	7 24
16	5	55 29	Laetitia 1379	+ 4 27.3	— 0 11
	6	2 8		27.8	+ 0 11
		8 21		28.3	17
		15 25		29.0	37
		21 39		29.1	48
17	5	35 37	B.A.C. 1334	+ 0 45.6	+ 11 35
		38 31		46.3	51
		41 9		46.2	49
		46 43		47.8	12 11
		48 35		47.4	22
		51 24		47.8	26
		53 46		49.7	28
		56 59		48.6	31
	6	1 23		49.0	54
		5 27		47.3	13 3

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Greenwich Mean Time.			Star.	R.A.		(North +)	
d	h	m		Comet—Star.	Decl.	Comet—Star.	Decl.
June 20	7	47	52	— 0	35° 3	+ 25	22
		52	16		34° 0		42
		55	38		33° 4	26	7
		58	33		33° 7	20	
	8	1	46		33° 5	36	
		5	7		32° 8	52	
		8	6		32° 4	27	5
		11	53		31° 7	24	

Star of 7th magnitude.
R.A. $4^h 23^m 15^s$
Decl. $-18^{\circ} 46' 30''$

The Longitude of the Sydney Observatory is $10^h 5^m 0^s$
Assumed Latitude $-33^{\circ} 51' 41''$

Observatory, Sydney, June 21st, 1861.

A later communication has been received, as follows:—

The accompanying observations are corrected for refraction and proper motion. There is some reason to believe that the assumed longitude of the observatory is 10^s too large, being deduced from Moon Culminations and the *Nautical Almanac* tables for 1859-60. It may, therefore, be desirable to add 10^s to the Greenwich mean times of observation.

Greenwich M.T.			Star.	Com.—Star.		(North +)		
d	h	m		R.A.	Log. Factor for Parallax.	Decl.	Log. Factor for Parallax.	
June 22	8	28 40	Wisee, IV. 655	—	10° 6	8° 68487	— 4 12	9° 64134
		31 23			10° 5	8° 68167	3 52	9° 63923
		33 29			10° 2	8° 67905	3 38	9° 63796
		35 49		—	9° 7	8° 67614	— 3 17	9° 63634
23	8	5 28	8th mag. Approx. Pos. R.A. 4 ^h 37 ^m 40 ^s Decl. — 10° 12'	—	47° 0	8° 70648	+ 5 31	9° 68390
		8 31			45° 9	8° 70368	5 46	9° 68278
		11 19			44° 8	8° 70100	6 12	9° 68094
		13 59			44° 2	8° 69840	6 30	9° 67963
		16 29			43° 5	8° 69585	6 51	9° 67842
		18 51	—	42° 9	8° 69347	+ 7 16	9° 67711	
25	7	40 31	Lelande, 9458.	—	45° 1	8° 72402	+ 0 22	9° 74049
		45 55			42° 9	8° 72063	1 42	9° 74032
		49 3			41° 5	8° 71866	2 21	9° 74026
		52 15			40° 6	8° 71649	3 18	9° 74018
		57 39			38° 2	8° 71262	4 19	9° 74001
	8	0 55			37° 0	8° 71015	5 10	9° 73997
		4 32		—	35° 4	8° 70724	+ 6 5	9° 73992

8th mag. Approx. Pos.
R.A. $4^h 37^m 40^s$
Decl. $-10^{\circ} 13'$

Lalande, 9458.

Greenwich M.T. ^d ^h ^m ^s	Star.	(North +)			
		Com.—Star. R.A.	Log.Factor for Parallax.	Com.—Star. Decl.	Log.Factor for Parallax.
June 26 7 46 24	Lalande, 9757.	— 32°2	8°72784	+4 51	9°75908
49 20		30°7	8°72618	5 47	9°75990
56 37		27°5	8°72170	8 7	9°76187
59 6		25°7	8°72008	8 45	9°76257
8 1 38		24°9	8°71836	+9 30	9°76323

The following orbit, computed by Mr. Hawkins of Goulburn, agrees very closely with the observed positions:—

Perihelion Passage, Greenwich Mean Time, June	11°75008
Perihelion Distance	0°822152
Longitude of Node	279 1 41
Inclination	85 37 46
Distance of Node from Perihelion	29 38 59
Heliocentric Motion	Direct.

Observatory, Sydney, August 11, 1861.

Observations of Comet II., 1861, made at the Dudley Observatory, Albany, U.S.A. By G. W. Hough, Assistant.

(Communicated by Professor Mitchell through the Astronomer Royal.)

M.T. Dudley Observatory.				App. R.A.			App. Decl.		
1861.	^h	^m	^s	^h	^m	^s	[°]	[']	^{''}
July 3	15	21	8°5	10	10	27°02	+66	33	2°82
5	13	39	8°37	12	0	12°54	65	58	6°92
7	11	22	30°00	13	1	53°67	63	7	51°90
12	11	0	41°50	14	7	46°17	56	58	22°76
18	9	6	23°86	14	35	6°21	52	42	33°05
21	15	33	13°70	14	43	26°60	51	10	38°40
23	11	53	46°64	14	47	9°63	50	27	56°72
25	9	42	52°04	14	50	31°27	49	48	51°23
30	11	9	55°95	14	57	53°45	48	23	20°54
Aug. 3	10	30	17°56	15	2	47°41	+47	29	14°87

July 3. Observed with the Olcott Meridian Circle at the lower Culmination. Fifteen wires observed in R.A. The remaining observations were made with the Equatoreal. The diff. in R.A. between the Comet and Comparison Star was determined by recording their transits (across three wires of the micrometer) in the Chronograph.

	Comp. Stars.	Comp.
July 5.	22785 L. L., 12372 Arg.	3
7.	24511 L. L., 13387 Arg.	3
12.	14403 Arg.	3
18.	14785 Arg.	3
21.	14869 Arg.	3
23.	14884 Arg., 4134 Rümker	3

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	Comp. Star.	Comp.
July 25.	14971 Arg., 4878 Rümker	4
30.	4922 and 4930 Rümker	6
Aug. 1.	4961 Rümker	5

The observations are not corrected for parallax.

And with the foregoing observations Prof. Mitchell also communicated—

Approximate Elements of Comet II. 1861.

1861, Washington M.T. June 11^h 668.

$$\begin{aligned} \omega &= 249^{\circ} 37' 7'' \\ \Omega &= 278^{\circ} 58' 1'' \\ i &= 85^{\circ} 23' 7'' \end{aligned} \left. \begin{array}{l} \\ \\ \end{array} \right\} \text{App. Eq., July 3^d 0}$$

$$\text{Log } q = 9^{\circ} 916390.$$

Direct.

From observations of July 3, 12, and 25.

Observations of Comet II. 1861, with the Equatoreal, at the United States Naval Observatory, Washington. By Mr. James Ferguson, Assistant Astronomer.

(Communicated by Commander J. M. Gilliss.)

M.T. Washington.			Comet—Star.		Comet's Apparent	
1861	h	m	Δ R.A.	Δ Decl.	R.A.	Decl.
July 2	9 55	19.3	+ 0 38.84	+ 5 58.79	8 43 6.97	+63 12 14.65
3	8 46	46.3	+ 12 12.30	— 4 22.69	9 51 41.15	66 9 52.46
"	9 10	7.3	+ 4 7.69	+ 11 36.35	9 52 52.55	66 11 36.73
4	8 51	20.5	+ 1 17.95	+ 16 51.38	10 58 36.26	66 54 20.63
6	9 0	52.5	+ 5 28.25	+ 19 35.73	12 31 12.57	64 51 7.59
8	8 51	54.0	— 1 8.74	— 6 34.76	13 20 47.48	61 50 8.93
12	10 10	53.1	— 1 40.65	+ 0 5.69	14 7 35.00	56 58 13.53
14	10 23	52.0	+ 5 23.97	— 15 15.40	14 19 45.09	55 14 25.87
16	9 10	58.8	— 0 36.04	+ 21 37.52	14 28 23.77	53 52 7.76
17	8 29	29.1	— 4 30.63	+ 15 1.99	14 31 53.61	53 16 40.10
20	9 55	15.2	— 4 26.76	— 14 35.12	14 40 37.21	51 42 28.91
23	9 1	48.1	— 4 50.84	+ 18 25.42	14 46 58.13	50 30 18.35
24	8 32	46.4	— 3 3.55	— 2 24.53	14 48 45.39	50 9 28.30
25	8 50	54.5	— 0 51.32	+ 10 36.52	14 50 29.23	49 49 16.30
27	9 0	37.5	+ 1 8.24	+ 15 31.25	14 53 38.04	49 12 26.44
30	8 27	55.7	— 1 29.14	+ 12 59.41	14 57 45.86	48 24 42.34
Aug. 1	8 42	5.6	— 1 4.48	— 15 37.36	15 0 19.43	47 56 5.37
4	8 48	54.9	— 2 18.08	— 4 55.72	15 3 52.88	47 17 34.70
6	8 46	10.2	+ 2 5.21	— 6 16.41	15 6 8.52	46 54 17.26
15	8 15	7.3	+ 1 56.99	— 4 52.68	15 15 53.75	+ 45 26 27.12

1861	No. of Comp.	Comp. Star.	1861	No. of Comp.	Comp. Star.
July 2	10	A.Z.N. 187.74	July 20	5	1668 Cat. Gen.
3	2	2396 Radcliffe.	23	7	†3293 Radcliffe.
"	5	A.Z.N. 176.26.	24	10	" "
4	12	" 176.13.	25	11	A.Z.N. 2.22.
6	4	" 186.96.	27	7	" 2.23.
8	9	" 203.66.	30	7	2317 Radcliffe.
12	5	* " 109.92.	Aug. 1	10	" "
14	5	" 5.8.	4	6	‡1697 Cat. Gen.
16	10	4760 Rümker.	6	5	§A.Z.N. 118.8.
17	3	Star 11.	15	7	" 118.21.

Mean places for 1860.0 of Comparison Stars.

		R.A.	Decl.	
		^h ^m ^s	[°] ['] ["]	
A.Z.N. 187.74	8.5	8 42 21.24	+ 63 6 30.15	Arg. Northern Zones.
2396 Radcliffe	6	9 39 22.18	66 14 32.14	Radcliffe Cat.
A.Z.N. 176.26	9	9 48 38.30	66 0 17.90	Arg. Northern Zones.
" 176.113	7	10 57 12.41	66 37 48.72	" "
" 186.96	8	12 25 39.35	64 31 51.80	{ Argel. N.Z. and Rümker.
" 203.66	9	13 21 51.68	61 57 2.60	Arg. Northern Zones.
* " 109.92	9	14 9 11.57	56 58 24.56	" "
" 5.8	7	14 14 17.03	55 30 33.18	{ Argel. N.Z. and Rümker.
4760 Rümker	7	14 28 55.39	53 30 47.85	Rümker's Cat.
Star 11	10	14 36 19.83	53 1 55.85	{ W. Equat. from A.Z.N. 1.39
1668 Str. Cat. G.	6	14 44 59.58	51 57 21.05	{ Struve Cat. G. and Rümker.
†3293 Radcliffe	5	14 51 44.56	50 12 10.09	Radcliffe and A.Z.N.
A.Z.N. 2.22	9	14 51 16.09	49 38 57.32	Arg. Northern Zone.
" 2.23	7	14 52 25.45	48 57 13.00	" "
3317 Radcliffe	7	14 59 10.68	48 12 0.57	Radcliffe Cat.
‡1697 Str. Cat. G. pr.	9	15 6 6.72	47 22 48.11	Struve and A.Z.N.
§A.Z.N. 118.8	8	15 3 59.12	47 0 51.96	Arg. Northern Zones.
" 118.21	7	15 13 52.55	+ 45 31 38.45	{ Argel. N.Z. and Rümker.

* The mean of 92 and 94 is used.

† This star is 4937 B.A.C. The mean of 3293 Radcliffe, and A.Z.N. 2.24 is used, without correcting for proper motion.

‡ The determination of 1697 Struve is of the sequent star, which is the same as A.Z.N. 118.9, but in the latter determination the declination is 10 minutes too small. It is also 4981 Rümker, who probably observed the preceding star. I have used a mean of Struve and Argelander for the sequent star, and applied the present observed differences for the place of the preceding star, which was used in the comparison.

§ The mean of 118.8 and 113.90 is used.

Mr. Francis Abbott, in a letter dated Hobart Town, June 22, 1861, addressed to Mr. Carrington, incloses a printed letter, giving an account of the same Comet II., 1861, as seen at Hobart Town, as follows:—

“ To the Editor of the Mercury.

“ Sir,— A notice was given in your issue of the 7th instant of a remarkably fine Comet, first seen at Hobart Town on the morning of the 4th, and at present appearing every clear morning in the south-eastern hemisphere, and in the evening near the south-western horizon. From its slow motion and general appearance it may continue for some time to be an object of interest in the southern sky. The comet's position first noticed was in the constellation *Eridanus*, the nucleus lying a little south of a small star marked 315 a. l.c.; it proceeded a little south of α and β , passing between them and 358, all stars of the 6th magnitude. The tail, which is quite straight and about 10 degrees in length, points in the direction of the star *Achernar*, the nucleus forming nearly a right angle with that star and *Canopus*. The nucleus of the comet, measured with a Cavallo's micrometer in an eye-piece of 50, was 33" in diameter; the coma or nebulosity surrounding the nucleus, as seen with a comet eye-piece of 27 in a 5-foot telescope, was 30 minutes in diameter. The breadth of nebulosity at the apex of the tail 50 minutes, where it becomes very diffuse.

“ The approximate positions of the comet, taken every clear morning to the present date, are as follows:—

1861.	Hobart Town M.T.	Comet's App. R. A.	Comet's App. Decl.
	h m	h m	o ' /
June 6	4 30 A.M.	4 2	30 20 S.
7	5 40	4 4	29 40
12	4 50	4 14	27 45
16	4 30	4 22	26 30
17	5 40	4 24	26 30
18	5 15	4 26	25 20
19	5 45	4 30	24 0
20	4 50	4 34	23 30

“ The comet is very like to the second comet of 1819, which was discovered by Professor Trallis at Berlin, July 1st, and made its appearance suddenly above the N.W. horizon, in the constellation *Lynx*; it was visible to the naked eye, with a bright tail and nucleus, until October 20th.

“ FRANCIS ABBOTT.

“ Murray Street, June 20th, 1861.”

Mr. Abbott remarks, however, that the right ascension and declination must only be considered approximate, as a few days before the comet appeared he sent his equatorial and azimuth instruments to Melbourne.

On the Form of the Shadow of Saturn's Ring.

By the Rev. T. W. Webb.

The following extract from the *Commentaries of the Royal Society of Sciences at Göttingen*, for the years 1791 and 1792, as published in this country in the *Memoirs of Science and the Arts*, may possibly be worthy of attention, in connexion with Mr. De La Rue and Mr. Lassell's very interesting observations of the irregular form of the shadow of the ring upon the globe of *Saturn*. It occurs in a description of the 13-feet reflector, by Schröder, of which Schröter made such extensive use, and which seems to have been an excellent instrument:—

"On the 26th of December, 1792, the writer (Schröter) observed *Saturn* with power about 300, and saw his belts, the southern broad, like a cloud, the nearest northern much more lucid than the remaining part of the surface, and the shadows which the body cast upon the ring and the ring upon the body. The boundaries of these shadows were jagged."

The irregularity of the shadow, as projected upon the ring, may possibly have been the deviation, so often remarked, where it crosses the principal division. The indentations of the shadow upon the globe may, perhaps, be thought analogous to those recently noticed; but in the case of Schröter's observation, though I have no means at hand of ascertaining the form of the ring in 1792, it is evident that it must have been much more open than at present, as otherwise the outline of the shadow projected upon it could not have been discernible.

Hardwick Parsonage, July 27, 1861.

Occultations of Stars by the Moon, observed at Forest Lodge, Maresfield, Sussex. By Capt. W. Noble.

Friday, June 14, 1861.

36 Sextantis.

The star disappeared instantaneously

at $14^h 18^m 45^s.8$ L.S.T. = $8^h 46^m 15^s.98$ L.M.T.

A dense haze of cirri prevented the observation of the reappearance. There was a great deal of atmospheric disturbance.

Tuesday, June 25.

18 Aquarii.

A thick haze surrounding the Moon deprived me of any chance of seeing the disappearance.

The star reappeared instantaneously
at $18^h 30^m 27^s.3$ L.S.T. = $12^h 14^m 1^s.2$ L.M.T.

π Capricorni.

	h	m	s		h	m	s
The star disappeared instantaneously at.....	19	39	6.2	L.S.T. =	8	4	0.2
and reappeared at.....	20	49	1.7	L.S.T. =	9	13	59.5
							L.M.T.

Saturday, September 14.

ϵ Capricorni.

The star disappeared instantaneously
at $20^h 53^m 12^s.8$ L.S.T. = $9^h 17^m 54^s.6$ L.M.T.

The reappearance was not observed. The atmospheric tremor was great. In all these observations my 4.2-inch equatoreal was employed, in each case with a power of 115 adjusted on the respective stars.

Captain Noble, in the letter which accompanied the foregoing observations, mentions as a curious fact that on Sunday evening, the 16th of June, while experimenting with the Hodgson eye-piece, upon lunar detail, he was surprised and amused to find that with powers of 160 and upwards the effect presented was a pseudoscopic one. The appearances of the Apennines as a deep and irregular depression in the Moon's surface, and that of the craters as large blisters, was, so to speak, absurd. Steady gazing caused this illusion to disappear, only to reappear again however after a short interval.

Occultation of Stars by the Moon, observed at the Dudley Observatory, Albany, U.S.A. By G. W. Hough, Assistant.

(Communicated by Professor Mitchell through the Astronomer Royal.)

	h	m	s	
ϵ Capricorni, Immersion, July 21,	23	18	28.1	Sid. Time.
16 Piscium, Immersion, July 25,	20	11	2.2	"

ϵ Capricorni, probably 0.2 slow.
16 Piscium: star seemed to hang on the edge of the Moon about 0.5 before it disappeared.

Mr. Ferguson, Observations of Leto and Virginia. 263

Observations of Leto and Virginia, with the Equatoreal, at the United States Naval Observatory, Washington. By Mr. James Ferguson, Assistant Astronomer.

(Communicated by Commander J. M. Gilliss.)

Leto ☉.

☉ — Star.						☉, Apparent					
M.T. Washington.			R.A.		Decl.		R.A.		Decl.		
1861	h	m	s				h	m	s		
June 13	9	39	4.7	— 0	15.87	— 4 56.57	13	42	13.97	— 10	24 12.11
14	8	58	28.3	— 0	24.47	— 6 13.71	13	42	5.36	— 10	25 29.21
18	8	54	48.8	— 0	45.47	+ 12 33.43	13	41	44.00	— 10	31 48.85

	No. of Comp.	Comp. Star.
1861, June 13	3	Weisse, XIII. 725
14	4	"
18	3	"

Mean place for 1860.0 of Weisse XIII. 725.

Mag.	R.A.	Decl.
9.5	13 ^h 42 ^m 23 ^s .48	— 10° 18' 38".52

Virginia ○.

					☉ — Star.		☉, Apparent						
M.T. Washington.				R.A.		Decl.		R.A.		Decl.			
1861	h	m	s	m	s			h	m	s	°	'	"
July 25	10	9	9.6	+ 1	0.79	— 17	22.67	20	7	48.90	— 16	2	27.49
Aug. 1	9	48	58.8	+ 3	51.51	+ 15	45.21	20	1	23.29	16	30	1.33
2	9	24	19.4	+ 2	58.77	+ 11	48.75	20	0	30.46	16	33	57.93
3	10	3	26.5	+ 2	3.88	+ 7	40.06	19	59	35.62	16	38	6.78
4	9	42	34.0	+ 1	11.95	+ 3	40.15	19	58	43.70	16	42	6.86
6	9	37	31.2	— 0	30.58	— 4	20.60	19	57	1.17	16	50	7.95

	No. of Comp.	Comp. Star.
1861, July 25	8	A.C. 20337
Aug. 1	10	" 20217
2	14	" "
3	11	" "
4	12	" "
6	11	" "

Mean places for 1860.0 of Comparison Stars.

	Mag.	R.A.			Decl.	Authority.		
		h	m	s	°	'		
A.C. 20337	9	20	6	40.13	-15	45	19.22	{ Argelander's Catalogue Southern Zones.
" 20217	7.8	19	57	23.70	16	45	58.10	

Mr. Ferguson, the discoverer of the planet $\textcircled{\text{a}}$ hitherto called *Titania*, has written to Mr. Hind, stating that this name was proposed without remarking its previous appropriation by Sir John Herschel for one of the satellites of *Uranus*, and intimating his intention to change it forthwith for *Echo*. This name will appear in the *Nautical Almanac* for 1865.

Discovery of a New Minor Planet, Niobe $\textcircled{\text{n}}$.

The planet was seen by Dr. Luther, as a star of the 11th mag., about 11 in the evening of the 13th August, R.A. $334^{\circ}52'$, Decl. $0^{\circ}7'$. On the following evening it was observed as follows:—

Bilk M.T.	R.A.	Decl.	
1861, Aug. 14 ^d 13 ^h 12 ^m 38 ^s .4	334 ^o 34' 58".3	—0 ^o 4' 41".5	10 Comp. with * a.

the daily motion being, therefore,

$$-16' \quad +2'$$

The comparison-star *a* (7, 8) was, according to a new determination by Prof. Argelander, at Bonn, assumed as follows:—

	R.A.	Apparent Decl.	Mean Position. 1861, o.	R.A.	Decl.
1861, Aug. 14	334 ^o 6' 17".2	—0 ^o 5' 10".4	334 ^o 5' 13".4	—0 ^o 5' 33".5;	

and hence the position of B. Z. 34, required the correction,

R.A.	Decl.
—4".6 (in arc)	—0".5

The following observations were taken at Bonn by Prof. Wolf:—

	Bonn M.T.	R.A.	Decl.
	h m s	h m s	o ' "
1861, Aug. 15	11 51 22.7	22 17 21.07	—0 2.5
	12 37 2.9	22 17 18.49	—0 2 37".4

Apparent Position of Star *a*.

Aug. 15	22 ^h 16 ^m 25 ^s .16	—0 ^o 5' 10".25
---------	---	---------------------------

The planet was also observed by Prof. Schönfeld, at Mannheim, as follows:—

	Mannheim M.T.	R.A.	Decl.
1861, Aug. 17	10 ^h 50 ^m 59 ^s	22 ^h 15 ^m 15 ^s .52	+0 ^o 1' 4".0

The foregoing account is calculated from the *Astron. Nach.*, No. 1323. Several later observations are published in subsequent Numbers.

Re-Discovery of Pseudo-Daphne (56).

M. Goldschmidt announces (*Astron. Nach.*, No. 1325) that, after a search of thirteen months, he has succeeded, August 27, in again finding this planet. This result is owing to the ephemeris of Dr. Luther and the Star-map, hora xx., of Dr. Hencke. The planet was of the 10-11 magnitude, and its position for August 28 was

	Paris M. T. (?)	R. A.	Decl.
Aug. 28	10 ^h 17 ^m	20 ^h 25 ^m 56 ^s	- 6° 48' 5

obtained by comparison with the star Lalande 39626 (8.9 mag).

Dr. Luther gives, in the same number, a new set of approximate (ganz flüchtig entworfen) elements, computed to connect the observations of 1857 and 1861, and to show that the planet is distinct from *Daphne*.

Pseudo-Daphne (56), *Elements III.*

Epoch 1857, Sept. 13^h 0 Berlin.

$$\begin{array}{rcl}
 M & = & 36^{\circ} 9' 5'' \\
 \epsilon & = & 294^{\circ} 40' 6'' \\
 \Omega & = & 194^{\circ} 39' 5'' \\
 i & = & 8^{\circ} 3' 5'' \\
 \phi & = & 13^{\circ} 7' 6'' \\
 \mu & = & 846'' \cdot 72
 \end{array} \left. \vphantom{\begin{array}{l} M \\ \epsilon \\ \Omega \\ i \\ \phi \\ \mu \end{array}} \right\} \text{Mean Equinox, 1861, 0.}$$

The Editor has received a communication from the Astronomer Royal as follows:—

“In a paper of official character, written by Lieutenant-General Bayer, Director of the Prussian Geodetic Survey, and circulated by the Prussian Government among the principal Governments of Europe, the following passage occurs:—

“‘Bessel hatt in Jahre 1841 aus 10 Breitengrad-Messungen die Abplattung $\frac{1}{299 \cdot 15}$, den Aequatorial-radius = 372077 Toisen bestimmt, Airy fand 8 Jahre später, aus 14 Breiten- und 4 Längen-grad Messungen, die Abplattung = $\frac{1}{299 \cdot 33}$ und den Aequatorial-radius = 3272120 Toisen.’

“That is to say, Bessel's investigations on the Figure of the Earth were made in 1841, and mine 8 years later, or in 1849.

“My investigations were made long before Bessel's. They are contained in an elaborate article on the ‘Figure of the

Earth,' in the *Encyclopædia Metropolitana*. In the printed book, the paper is dated at the end 'August 17, 1830.'

"I do not indicate this error in any spirit of complaint against General B yer, whose honourable character is perfectly appreciated in this country. But it is an instance proving that the progress of science in Britain is little known on the Continent; and that a historian of science, in order to avoid error, must carefully examine the literature of the country in which each scientific author has lived and has written."

Mr. Andrew Lang, who (as he mentions in his letter) has been a Fellow of the Society since 1821, and is 82 years of age, has sent an account of the Solar Spots observed by him in the Island of St. Croix, in the West Indies, during the year 1860. The observations were always made in the morning, from 7 to 8 o'clock, with an inverting eyepiece, magnifying 40 times, by Gilbert, applied to a telescope 44 inches focal length and $3\frac{1}{2}$ inches clear aperture, by Banks. Mr. Lang writes that he has in vain looked for *Vulcan*.

In the *Comptes Rendus*, 3 June, 1861, M. Le Verrier announces the completion of his researches on the motion of the planet *Mars*, and he considers the consequences, in regard to the physical constitution of the Solar System, which are to be derived therefrom in connexion with his former researches on the motions of *Mercury*, *Venus*, and the Earth. The theories of *Venus* and *Mars* agree in showing, that in order to obtain from theory the actual motions of the perihelia of these planets it is necessary to increase by about one-tenth part the mass of the Earth; but the actual motion of the perihelion of *Mercury* cannot be accounted for by means of this change; and as the received mass of *Venus* could not be altered, M. Le Verrier was thus led to conclude the existence of a ring of intra-mercurial masses. A group of asteroids exists as we know between *Jupiter* and *Mars*, and there is reason to believe that there are circulating round the Sun, in planetary space, a large number of very small bodies; as regards the region in the neighbourhood of the Earth's orbit this is certain. Thus, without the above-mentioned alteration in the mass of the Earth, M. Le Verrier obtains with respect to the constitution of the inferior part of our planetary system as deduced from the discussion of the observations, the following conclusions:—

1^o. Besides the planets *Mercury*, *Venus*, the Earth, and

Mars, there exists between the Sun and *Mercury* a ring of asteroids, the aggregate of which constitutes a mass comparable to that of *Mercury*.

2°. At the distance of the Earth from the Sun there is a second ring of asteroids, the mass of which is at most equal to a tenth part of the mass of the Earth.

3°. The total mass of the asteroids between *Mars* and *Jupiter* is at most equal to one-third of the mass of the Earth.

4°. The masses of the last two groups are complementary to each other; ten times the mass of the group situate at the distance of the Earth, plus three times the mass of the group situate between *Mars* and *Jupiter*, gives a sum equal to the mass of the Earth.

This last conclusion depends on the measure of the distance of the Earth from the Sun by the observation of the transits of *Venus*, which astronomers agree in considering as very precise.

INSTRUMENTS AND BOOKS FOR SALE.

The family of the late E. J. Burrow, D.D., Archdeacon of Gibraltar, are desirous of disposing by sale of his astronomical instruments and books, namely:—

1. A best constructed $3\frac{1}{4}$ -feet achromatic telescope, with $3\frac{1}{4}$ -inches object-glass, achromatic finder, sliding steadies, 6 eye-pieces, powers from 40 up to 200, a ring, and a wire micrometer with accommodation metal (adapted to all the eye-pieces) and 4 eye-pieces in white metal, powers from 70 to 180. The tube, in brass, is fitted to a strongly mounted and newly constructed $8\frac{1}{2}$ -inch equatoreal, with 3 spirit-levels, strong upright supports, metal axis, graduated declination arc, with clamps, &c., and azimuth and hour-circle plates, and 2 sets of verniers reading off to 12 seconds of time and one minute of space.

The instrument was made by Jones of Holborn, in August 1854, without regard to cost, and is in a high state of preservation. It is now placed for inspection under the care of Mr. J. Williams, the Assistant Secretary, at Somerset House, who is authorized to exhibit the bills of sale, and to treat with any party wishing to become a purchaser.

2. A journeyman clock, striking minutes and half-minutes. Also,

3. A set of "Pearson's Astronomy," 2 vols., and a vol. of Plates, large 4to. boards, and

4. Baily's Catalogue of Stars of the British Association.

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MONTHLY NOTICES
OF THE
ROYAL ASTRONOMICAL SOCIETY,
CONTAINING
PAPERS,
ABSTRACTS OF PAPERS,
AND
REPORTS OF THE PROCEEDINGS
OF
THE SOCIETY,
FROM NOVEMBER 1861, TO JUNE 1862.

VOL. XXII.
BEING THE ANNUAL HALF-VOLUME OF THE MEMOIRS AND PROCEEDINGS
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1862.



MONTHLY NOTICES
OF THE
ROYAL ASTRONOMICAL SOCIETY.

VOL. XXII.

November 8, 1861.

No. 1.

Dr. LEE, President, in the Chair.

Col. T. Schaffner, Kentucky, U. S. A.,
was balloted for and duly elected a Fellow of the Society.

*Extract of a Letter from Professor Hansen to the Astronomer
Royal, dated Gotha, 1861, Oct. 18.*

My principal labours advance progressively, and I work at them with pleasure. Events in the last summer have indeed occasioned some delay, and my other various avocations also often create cessations, but nevertheless I proceed. The working out of the new terms depending upon the planets, which I mentioned in my last letter, has occasioned a considerable addition to the labour of the calculation of the secular variation of the Moon's mean longitude, which I have not yet quite completed. I must in fact execute in regard to these terms as great a labour as in the calculation of the lunar perturbations themselves. I must carry on the approximations until the values at last substituted come out again. These terms are far greater than I suspected at first, and the circumstance that here the coefficients of the terms which have very small divisors become remarkably large particularly increases this labour. In the lunar perturbations themselves the analogous terms have only small coefficients. I am, I may say, perfectly

convinced that the value of the secular variation which I have before calculated from theory and assumed in the Lunar Tables must again come out, although I have considerably changed the method of calculation.

In the calculation of the secular variation of the mean longitude, I have set out with the proposition that the element which I have always denoted by $\mathfrak{z}$ has no influence over it. This proposition I have already proved, even to the cube of the disturbing forces, in my third memoir upon the perturbation of the small planets, and the proof holds also for the Moon. Further, the numerical equations of condition have shown me that this proposition is true even for the higher powers of the disturbing forces, at least to a considerable extent.

I have calculated anew the principal part of the perturbations of the longitude, of the radius vector, and of the latitude, and obtained such an agreement with the coefficients used by me in the Lunar Tables, and derived from the previous theoretical calculations that the differences in the individual coefficients amount only to a few hundredths of a second of arc. A new calculation of the secular variation of the motion of the perigee is also finished, and the deviation of the coefficient thus found from that of the Lunar Tables scarcely amounts to $0''.4$. Now this coefficient, multiplied only by $2e$, enters into the longitude; and as $2e$ is nearly $=\frac{1}{2}$, this difference is of no greater significance than $0''.04$ in the coefficient of the secular variation of the mean longitude.

As I have brought such accuracy into my theoretical determinations of the various parts of the Lunar Theory, it of course follows that I do not need to deem the cry which some have raised concerning empiricism finding place therein deserving of the least notice.

In order, however, as much as possible to comply with every reasonable desire concerning the early publication of my theoretical determination of the coefficients of the Lunar Theory, I have occupied myself, for some short time past, with putting together and sending to the press my calculation of the principal perturbations, which, as stated above, has been executed afresh. As soon as possible will follow, also, the publication of the calculation of the smaller coefficients. You will ask perhaps why I then do not publish the first calculations, which were finished long ago, before the completion of the Lunar Tables? and I answer, that I executed the last approximations in that calculation by substitution of the differences with the preceding approximation, and that therefore, by the publication of these calculations, a complication would arise which could only be made intelligible with great difficulty.

In the publication the result must proceed from *one* fountain; and it was necessary, therefore, that a new approximation should be calculated, with the full values of the coefficients. Only in this manner can I make myself clear, and place every

one in a position to be able to examine with ease the individual parts of my calculation.

With regard to the two small errors in the Lunar Tables which you communicate to me, they have arisen in this manner:—Page 86, Arg. 37 and (a) have, according to my present re-calculation, been calculated by my former computer, who has made so many errors, with an incorrect coefficient of $(c-18)^3$. The influence of this error, however, is so insignificant that it can, even in the year —800, produce an effect, at the most, of $1''\cdot8$ upon the Moon's longitude, and, as a matter of course, still less in subsequent centuries. I consider, therefore, its correction to be superfluous. Page 77, Arg. 10, Year —500, 56'619 was written by mistake instead of 56'691.

Note by the Astronomer Royal.

The small errors to which Professor Hansen alludes in the last paragraph were pointed out by Dr. Hincks to the Astronomer Royal, in a letter dated 1861, Sept. 16. Dr. Hincks remarks, "The whole columns 37 and (a), p. 86, are miscalculated, the error in the former being proportional to the cube of the number of centuries before 1800. $9^{37}1823 + 275$ ought to be $9^{1350} + 330$; and so in other instances down to 1600, when the error disappears. I happened to notice a minor error in p. 77, —500, Arg. 10, where 56'619 is printed for 56'691. This, however, produces no sensible error."

On a Result deduced by M. D'Abbadie from Observations of the Total Solar Eclipse of 1860, July 18. By the Astronomer Royal.

In the *Compte Rendu* of the French Academy for the meeting of 1860, November 12 (tome li.), M. Antoine D'Abbadie has given an account of his observations of the eclipse of July 18, and in particular of his measures of the height of a certain red prominence A, to which my present remarks are confined. The telescope employed had an aperture of $72^{\text{mm}}\cdot5$ (2·9 inches nearly), a focal length of 800^{mm} (32 inches nearly), and was used with a magnifying power 47. The micrometer consisted of a glass plate in the field of view, bearing a net of equal divisions, which divided the whole field into squares of $51''$ each side.

Omitting all observations except those which I have specified, M. D'Abbadie's record is as follows:—

4 *Astronomer Royal, on a Result deduced by M. D'Abbadie*

No. de l'Observation.	Temps Moyen.	Phénomène Noté.	Angle réduit en hauteur.
	^h ^m ^s		
3	2 47 45	{ Hauteur de A, 1.3 division (probablement 2.3). }	1.9
5	2 48 26	{ Hauteur de A, 1.3 division, dont une en diagonale. }	1.4
7	2 49 27	Hauteur de A, 0.7 division.	0.6

upon which he founds the following inferences:—

“En calculant le mouvement relatif des deux astres par les Tables de MM. Hansen et Le Verrier, et en comparant les différences à celles qu'on déduit de mes observations relatives ci-dessus, on obtient les résultats suivans,—

Numero.	Diminution observée dans la hauteur de la prot. A.	Mouvement correspondant calculé de cette partie du disque.	Mouvement maximum calculé dans la direction même du mouvement relatif des deux astres.
De 3 à 5	30	15.0	18.3
De 5 à 7	52	22.4	27.2

“Ici, la décroissance observée est plus de deux fois celle qui serait produite par le simple mouvement relatif des deux astres.”

We owe it entirely to the candour of M. D'Abbadie and to the completeness of his published statement, that we are in any way enabled to criticise his conclusions. I trust, therefore, that, in expressing my inability to agree with M. D'Abbadie as to the method of treating his observations and as to the results to be drawn from them, I may be understood as offering to him my thanks and those of other persons interested in this discussion, for the clear and full account of his original observations, from which we are all enabled to frame our own deductions.

The conclusion of M. D'Abbadie regarding the discordance between the observed decrease of the prominence and the computed change in relative positions of the Sun and Moon, rests *entirely* upon his arbitrary correction of the first observation; where his recorded measure was 1.3, which measure he has changed with the simple remark “probablement 2.3”, and has used so changed in the subsequent computations. There is nothing to lead to the supposition that any circumstance attending the observation itself called for a change. It has been made, as far as we can judge, simply because the progress in the measured height of the protuberance between 3 and 5 is inconsistent with that between 5 and 7: it has, in fact, the wrong sign.

But if we are permitted to make such changes, where shall we stop? Why not alter the measure 5 instead of 3, which would have led to a discordance in the opposite direction? I conceive that it is much safer to use the observations as they

stand, to extract from them the best result which mathematics enable us to draw, to form the numerical values of the residual errors, and to judge whether these can properly be attributed to error of observation.

Adopting, then, for observation 3 the *original* value 1.3, and considering the diagonal measure in observation 5 as 1.4, we have the following measures of the height of the prominence:—

No.	Mean Time.	Height of A in divisions.	Height of A in seconds.
	^h ^m ^s		
3	2 47 45	1.3	66
5	2 48 26	1.7	87
7	2 49 27	0.7	36

Let x be the height of the prominence at 2^h 47^m 0^s, y the decrease in its height for 1^m. Then we have

$$x - y \times 0.75 = 66$$

$$x - y \times 1.43 = 87$$

$$x - y \times 2.45 = 36$$

Treating these by the method of Probable Errors, we obtain the equations

$$3x - y \times 4.63 = 189.0$$

$$x \times 4.63 - y \times 8.60 = 262.1$$

by solution of which, $x = 93.8$, $y = 20$.

The rate of change for 1^m, therefore, inferred from the observations, is 20", agreeing sensibly with 22" given by the computed relative motion of the Sun and Moon.

If we substitute for the formula $93.8 - 20 \times t$ (where t is expressed by fractions of a minute) in each of the observations, we obtain

No.	Computed Height of Prominence.	Observed Height of Prominence.	Excess of Observed Height.
3	78.8	66	-12.8
5	65.2	87	+21.8
7	44.8	36	-8.8

From my own experience in observations of eclipses, I conceive that these "excesses," though very large, are not beyond possibility. The second measure (in which it seems to have been necessary to resort to a comparison with the diagonal of the square, I can scarcely imagine why) was evidently made under unfavourable circumstances; and the power of the telescope was low.

I think that M. D'Abbadie's inference is not sustained by his observations.

Royal Observatory, Greenwich,
1861, October 22.

Total Solar Eclipse, 1861, Dec. 31.

By J. R. Hind, Esq.

The following Table, exhibiting the path of the Moon's shadow over the African continent, in the eclipse of 1861, Dec. 31, has been derived from accurate calculations founded upon the Tables of Le Verrier and Hansen, assuming the diameters of Sun and Moon as there adopted:—

Green- wich Mean Time.	N. Limit.		Central Line.		S. Limit.		Duration of Total- ity on Central Line.
	Long.	Lat.	Long.	Lat.	Long.	Lat.	
^h ^m	[°] [']	[°] [']	[°] [']	[°] [']	[°] [']	[°] [']	^m ^s
2 33	18 13 W.	14 30 N.	18 8 W.	14 11 N.	18 2 W.	13 52 N.	1 43
2 38	16 24	15 36	16 19	15 18	16 14	15 0	1 38
2 43	14 28	16 49	14 23	16 32	14 18	16 14	1 33
2 48	12 21	18 10	12 17	17 53	12 13	17 35	1 27
2 53	10 1	19 40	9 58	19 23	9 54	19 6	1 20
2 58	7 23	21 21	7 21	21 5	7 18	20 49	1 13
3 3	4 18	23 19	4 17	23 3	4 16	22 47	1 5
3 8	0 32 W.	25 40	0 33 W.	25 25	0 33 W.	25 10	0 56
3 10	1 17 E.	26 45	1 15 E.	26 31	1 14 E.	26 16	0 52
3 12	3 22	27 59	3 19	27 45	3 17	27 32	0 48
3 14	5 50	29 25	5 47	29 12	5 44	28 58	0 43
3 15	7 18	30 15	7 14	30 1	7 10	29 48	0 40
3 16	9 0	31 10	8 54	30 57	8 48	30 44	0 37
3 17	11 2	32 16	10 53	32 2	10 46	31 49	0 34
3 18	13 42 E.	33 39 N.	13 29 E.	33 24 N.	13 17 E.	33 9 N.	0 31

Nautical Almanac Office,
1861, Nov. 2.

Observations of the Solar Spots. By Rev. F. Howlett.

Mr. Howlett presented to the Society a further series of drawings of solar spots. The following is extracted from the letter, dated St. Augustine's Parsonage, Hurst Green, Sussex, Nov. 5th, 1861, which accompanied the drawings:—

"The present series, continued from Nov. 15th, 1860, and brought down to Oct. 31st of the present year, consists of about seventy-three drawings of the whole solar disk, as magnified about 30 diameters, besides upwards of 200 separate spots, grouped or single, as amplified from 120 to 150 diameters.

"I may be permitted to remark that the wonderful commotions exhibited on the solar surface during the years 1859 and 1860 have scarcely, I think, been equalled at any period during the year which is now drawing to a close. These commotions,

indeed, would appear to be now calming down—consistently, so far, with the much-discussed eleven-year cycle of maximum and minimum of spots.

“At no time, however, this year have I ever observed the Sun to be entirely devoid of spots: the two barest days might, I think, be stated as the 1st Feb. and 9th Oct. last, as may be inferred from the condition of the disks when respectively depicted on the 2d Feb. and 10th Oct. (as shown in sheets Nos. 37 and 58); whilst the spots of the latter part of March, and of the last half also of April and May, were very grand (as see sheets Nos. 41, 43, 44, and 47, especially the last).

“The preponderance of spots occurred, as usual, in the Sun’s northern hemisphere; indeed, during the ninety-nine days upon which I made records of these appearances, I found, as nearly as I could judge, that a northern preponderance obtained on 47 days, and a southern one on 28; the spots on the remaining 24 days of recorded observation being nearly equally distributed in both hemispheres.

“The longest series that I have been able to depict of the changes undergone by any one individual spot is that exhibited in nine separate drawings of the spot ν (see sheets 43 and 44), between the period of its first being observed by me on the 16th April and the condition it was in on April 26th, including the alteration suffered even between the hour of 7:30 A.M. and 3:0 P.M. on April 17th.

“A peculiar eddy seems to have strongly characterised the spot numbered 2, in group χ (sheet 54), as observed at 6:20 A.M. on July 29th, but which had nearly ceased, judging from appearances, at 2:15 P.M. on the same day.

“I may also, perhaps, be allowed to call attention to the manner in which I have endeavoured to represent, approximately, the inclination to the horizon, at different hours of the day, of the line of junction of two spots on the Sun’s surface, as recorded also on July 29th. The subject is interesting, as far as the matter of spherical geometry is concerned; and not less so, perhaps, as regards the best time for drawing the solar disk—in the way, at least, with which I am obliged at present to content myself, as alluded to in my last communication to the Society.

“The absence of penumbra on the north-east side of so large a spot as β (see Aug. 19th, sheet 56) is, I should imagine, very unusual.

“I would only desire to remark, further, the impression which is increasingly felt by me of the extreme *shallowness*, by comparison, of the photospheric stratum in which is sunk the penumbra of spots generally, and even of the penumbral stratum itself; inasmuch as the nuclei commonly remain visible to almost the very edge of the disk, the penumbral border of a spot very seldom presenting much appearance of foreshortening, either; so far, at least, as I could perceive, though armed with

8 Mr. Birt, Description of a portion of the Lunar Surface

a Dawes's solar eye-piece, by Dollond, with a magnifying power of 200 diameters, and with an ordinary astronomical eye-piece, of about 300 diameters, appertaining to one of the Society's Sheepshanks Equatoreals, by Simms.

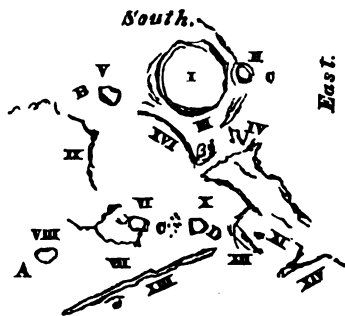
"This assumed shallowness of the *photosphere*, indeed, seems *proved* by Mr. Nasmyth's most interesting discovery of the thin layer of luminous lenticular bodies, of which that observer asserts the solar surface to consist.

"On the other hand, the *nuclear stratum*, or perhaps *strata*, appears to be of prodigious thickness, as may be inferred from the evidently vast depths into which the nuclear orifices descend, and as the varying intensity of blackness in different parts of the same nucleus seems also to bespeak. See series of large spot ζ throughout sheet 41, and series also of the grand spot ν in sheets 47 and 48, where the idea seems forced upon one, of chasms descending through cloudy strata, dozens or perhaps rather scores of thousands of miles in perpendicular depth."

Description of a portion of the Lunar Surface seen at Dr. Lee's Observatory at Hartwell, on the morning of July 31, 1861.
By W. R. Birt, Esq.

The Roman numerals refer to the accompanying sketch which is taken from Beer and Mädler's map of the Lunar Surface.

I. *Cichus*.—A deep crater on the south-west extremity of a very rugged portion of high land, forming part of the south-east boundary of the *Mare Nubium*.



Mr. Webb thus speaks of *Cichus*:—

"*Cichus*, 189, on index map, a crater opened in table land, lies 9000 feet beneath the plateau, 4000 feet below the plain; its ring is perforated by a smaller crater, an object of

great interest. In 1833 I perceived that it was twice as large as it had been represented three several times by Schröter. On becoming possessed of the great map, I found it there also enlarged. Schröter, though a clumsy, was a faithful draughtsman; his views have the appearance of being each independently drawn, and they are under different angles of illumination, which often vary the size of small craters, so that here is *fair evidence of volcanic action* since 1792; the silence of Beer and Mädler being characteristic, goes for little or nothing."

Webb gives two figures; one, copied from Schröter's design, 1792, Jan. 4; the other, taken from Beer and Mädler's map. I am not in possession of Schröter's.

II. *Cichus* A, marked C in Beer and Mädler's map, a small but deep crater on the south-east margin of the ridge of *Cichus*. This small crater should be most carefully watched and measured; only a portion of the margin was seen this morning, as a projecting tongue of light into the dark shadow within the larger crater.

III. A crater north of *Cichus*, given in the small German map, but singularly omitted in the large map. There is a very obscure marking in the neighbourhood of the fault next to be described, *where I saw the crater exceedingly well defined*; but it has on the map not the remotest resemblance to a crater: it is situated between two mountain masses marked β and γ . This is also an object that requires close attention.

IV. A fault north-east of III., forming the south-west portion of a somewhat narrow triangular mass of very high land, about 5000 feet; see quotation from Webb. It is also very rugged. This mass of high and rugged land is well shown on the large German map.

V. A small crater west of *Cichus*, marked B on the large German map.

VI. A crater near the boundary of the *Mare Nubium*, forming with III. and V. an isosceles triangle, III. and V. being the base. The position of this crater, as I saw it, does not accord with its position on the large map. I apprehend it to be really more southerly than marked by Beer and Mädler. Westward of this are *four* small craters, which I failed to see. *Query*, were they too much advanced on the terminator?

VII. A portion of high land, on the south-east extremity of which *e* (VI.) is situated. The small German map gives a ridge hereabout; it does not, however, terminate as I saw it. It is very much better delineated on the large map.

VIII. A crater marked A on the large map, on the east edge of *Hesiod*, which is now on the terminator. Its outline is perceptible, but the floor is in perfect darkness.

IX. The east edge of a crater now in shadow, which does not appear to be given in the German map. The east ridge is, however, well given in the large map; it is connected with the

boundary of a large space south of *Hesiod*, presenting (on the map) the appearance of a large disrupted crater (unnamed).

X. A small crater marked D on the large map: it is north-east of *e* (VI.)

XI. A small crater nearly, but not quite, in a line with VI. and X., also given in the German maps, but delineated in the larger map as being much more diminutive in comparison with the craters in its neighbourhood than I saw it. It is *undesignated*, probably as having been an inconspicuous object at the date of Beer and Mädler's labours.

XII. A small serpentine mountain chain between X. and XI. given in the German maps.

XIII. A rille or canal brought out most exquisitely by the Hartwell telescope, but no traces of its consisting of minute craters, although examined with a power of 416. The utmost I could detect was a very narrow gutter-like formed canal running north-west and south-east, or thereabout, from *Hesiod* to near the steep and rugged south-east boundary of the *Mare Nubium*, the north-east interior slope being in shadow, the south-west in sunshine. I estimated it to be somewhat about a mile wide. It is well delineated on the German map, and is marked *δ*.

XIV. A short mountain-range running nearly at right angles from one extremity of the triangular mass of high land, described at IV., and at right angles generally to the steep and rugged boundary of the *Mare Nubium*, to the two craters *Mercator* and *Campanus*. It is given very distinctly on the larger map.

XV. A small conical mountain (?) very apparent north-east of, and closely abutting on, the rille or canal XIII. (*δ*). This is not given on the German map, and no traces whatever can be seen on the larger map. It would be well to watch very closely the neighbourhood of this mountain, especially as the surface of the *Mare* is exceedingly smooth, north-east of the canal.

XVI. Western edge of the high land forming the south-west part of the mass on which *Cichus* is situated; shown on the large map.

From VI. in the direction of X. towards XII., and as far as XIV., the surface is studded with small mountains (hillocks in comparison with the larger mountain masses), clearly separating the smoother spaces within IX. and XVI. from the general surface of the *Mare*. This appearance of being thus studded is shown on the larger map. The space between IX. and XVI. being separated from the general surface has greatly the appearance of having been a portion of a large ancient crater, probably broken up by the formation of this portion of the boundary of the *Mare Nubium*.

The above described observations were made with Dr. Lee's great Equatoreal, object-glass by Tully, on July 30, 1861, between 13 and 15 hours G.M.T. Power employed 240.

The Lunar Crater Plato.

Mr. Birt communicated a series of observations of this well-known crater, embracing a period of eighteen months, viz., from January 1860 to July 1861, which he had arranged according to the Moon's age, so that they not only served as a record of the past, but can also be used as an Ephemeris, indicating to the observer the appearances likely to be seen, and thus form the basis of an accurate course of observations on the physical aspects of *Plato*, and by means of which changes, if any, may be detected. There are several sketches of the spot and also portions of it. The observations are preceded by an index, referring to the Moon's age at which each observation was made, and followed by a summary of objects suitable for further telescopic observation in or near *Plato*. The whole are bound in a volume, which is deposited in the Library for reference and circulation.

On an Instrument for comparing Colours, proposed to be designated a Homochromascope. By W. R. Birt, Esq.

In the course of my observations on the physical characteristics of the Moon's surface, I found it necessary to devise some means for comparing with known standards of colour the tints of various portions, especially the dark-floored craters, the extensive grey plains, and the more luminous districts in immediate proximity with the rayed craters. After various trials, I found the instrument of which a somewhat rough model is now exhibited* the best adapted for the purpose. It is intended to consist of a moveable cradle, possessing a rack-work motion receiving one of a series of glass plates; on each plate a certain number of disks are painted with transparent colours, each colour being experimentally determined by means of an instrument similar in its construction and action to the colour top. The numerical value of every tint can thus be precisely ascertained. The cradle, with its plate of glass, is moved within a box having a circular aperture, top and bottom, exactly equal to the coloured disk; so that, while the strong light of a lamp enclosed in a lantern is thrown on a highly reflective surface attached to the box, the disk is viewed by the light thus reflected and transmitted through it. In this way, while the eye carefully contemplates the tints of the lunar disk, it is also able to compare them with the tints

* The model was exhibited at the Meeting.—Ed.

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on the glass plates, which, being properly arranged and numbered, the tints observed can be easily registered. The instrument, mounted on a tripod, may be conveniently placed near the telescope for observation.

It is highly important that, in all observations with an instrument of this kind, the flame of the lamp should always be of the same intensity. This may be secured by a simple arrangement in the construction of the lamp and the burner. The construction of the instrument ensures permanency of tint in every other respect.

Results of the Meridional Observations of Small Planets ; Occultations of Stars by the Moon ; and Phenomena of Jupiter's Satellites : observed at the Royal Observatory, Greenwich, during the months of June to October, 1861.

(Communicated by the *Astronomer Royal*.)

Iris (7).

Mean Solar Time of Observation.	R.A. from Observation.			N.P.D. from Observation.		
	h	m	s	h	m	s
1861, June 5	9	55	0.1	14	52	12.22
12	9	23	6.8	14	47	49.58
						

Irene (14).

Mean Solar Time of Observation.	R.A. from Observation.			N.P.D. from Observation.			
	h	m	s	h	m	s	
1861, Oct. 4	13	54	11.2	2	49	5.82	85 6 19.01
11	13	21	52.4	2	44	17.64	85 32 41.28
22	12	29	31.3	2	35	10.04	86 13 6.78
26	12	10	9.7	2	31	31.46	86 26 30.64

Phocæa (20).

Mean Solar Time of Observation.			R.A. from Observation.			N.P.D. from Observation.			
	h	m	s	h	m	s	°	'	"
1861, Sept. 20	12	18	24.9	0	17	51.36	65	43	23.93
26	11	50	33.2	0	13	35.10	67	34	32.82
27	11	45	55.0	0	12	52.76	67	54	11.71
30	11	32	2.8	0	10	47.92	68	54	43.27
Oct. 4	11	13	41.3	0	8	9.61	70	18	14.85
9	10	51	5.8	0	5	13.14	72	5	4.88
11	10	42	11.6	0	4	10.62	72	48	3.05
19	10	7	30.7	0	0	56.37	75	36	38.05

Calliope (20).

Mean Solar Time of Observation.	R.A. from Observation.			N.P.D. from Observation.			
	h	m	s	h	m	s	
1861, Sept. 12	11	12	25.4	22	40	9.31	120 47 44.84
Oct. 4	9	31	33.1	22	25	44.66	120 21 49.34

Bellona (26).

Mean Solar Time of Observation.	R.A. from Observation.			N.P.D. from Observation.			
	h	m	s	h	m	s	
1861, Sept. 23	13	1	35.4	1	12	59.30	93 17 12.29
Oct. 11	11	37	21.9	0	59	29.91	95 27 52.16
14	11	23	13.2	0	57	8.58	95 46 52.83
22	10	45	49.0	0	51	10.66	96 30 55.27

Urania (28).

Mean Solar Time of Observation.			R.A. from Observation.			N.P.D. from Observation.			
	h	m	s	h	m	s	°	'	''
1861, June 27	11	52	14.4	18	16	30.02	115	22	39.46
July 4	11	17	8.8	18	8	54.64	115	19	3.65
11	10	42	33.5	18	1	49.51	115	12	54.83

Ariadne (32).

Mean Solar Time of Observation.	R.A. from Observation.			N.P.D. from Observation.			
	h	m	s	h	m	s	
1861, Sept. 10	13	56	51.2	1	17	9.01	75 32 46.37
Oct. 11	11	26	51.5	0	48	57.79	78 24 5.09
14	11	12	9.8	0	46	3.36	78 46 39.54
19	10	47	58.9	0	41	31.32	79 24 28.19
22	10	33	41.0	0	39	0.68	79 46 29.44

Nysa (41).

Mean Solar Time of Observation.	R. A. from Observation.	N.P.D. from Observation.
	h m s	o ' "
1861, June 15	11 19 30.1	16 56 21.70
		107 57 28.05

Europa (59).

Mean Solar Time of Observation.	R.A. from Observation.			N.P.D. from Observation.			
	h	m	s	h	m	s	
1861, Oct. 4	12	7	18.3	1	1	55.42	93 56 7.94
22	10	43	46.1	0	49	7.39	95 22 52.42

Pseudo-Daphne (66).

Mean Solar Time of Observation.			R.A. from Observation.			N.P.D. from Observation.		
	h	m	s	h	m	s	°	'
1861, Sept. 3	9	33	5.8	20	25	4.37	97	36 41.29
5	9	25	11.9	20	25	2.31	97	51 51.54
12	8	58	33.7	20	25	55.59	98	43 11.06

Niobe (71).

Mean Solar Time of Observation.			R.A. from Observation.			N.P.D. from Observation.		
	h	m	s	h	m	s	°	'
1861, Aug. 19	12	19	43.9	22	13	1.62	89	55 19.32

All the observations of N.P.D. have been corrected for refraction and parallax, excepting that of *Niobe*, which has been corrected for refraction only.

Occultations of Stars by the Moon.

Day of Obs.	Phenomenon.	Moon's Limb.	Mean Solar Time.	Observer.
			h m s	
1861, June 25	18 Aquarii, disapp.	Bright	11 39 59.1	D.
Sept. 14	♄ Capricorni, disapp.	Dark	8 3 44.0	E.
14	♄ Capricorni, disapp.	Dark	9 17 44.1	E.
14	♄ Capricorni, reapp. (a)	Bright	10 29 55.3	E.
Oct. 20	ξ Arietis, disapp.	Bright	7 16 34.0	N.
22	103 Tauri, disapp.	Bright	12 35 58.4	M. D.

(a), Perhaps doubtful to one or two seconds.

The initials D., E., M. D., and N. are those of Mr. Dunkin, Mr. Ellis, Mr. Dolman, and Mr. Newcomb.

Phenomena of Jupiter's Satellites.

Day of Observation.	Satellite.	Phenomenon.	Mean Solar Time.	Observer.
			h m s	
1861, June 12	I.	Occ. disapp, first cont.	9 57 15.0	C.
12	I.	„ total disapp.	9 59 44.5	C.
13	I.	Egress, bisected. (a)	9 40 51.5	J. C.

(a) The planet very tremulous and diffused.

The initials C. and J. C. are those of Mr. Criswick and Mr. Carpenter.

Occultation observed at Highbury. By T. W. Burr, Esq.

1861, September 14th. The star ϵ Capricorni was occulted instantaneously by the dark limb of the Moon at $20^h 52^m 38^s.9$ local sidereal time. Telescope 4 ft. 4 in. focus, $3\frac{1}{4}$ in. aperture, power 173. Longitude 24° W.

Nov. 7th, 1861.

Places of the Comet II., 1861, from Sextant-Observations of the Distances of the Comet from Fixed Stars, made by Commander A. L. Mansell, R.N., commanding H.M.S. Firefly, and reduced under the superintendence of the Rev. George Fisher, Principal of the Greenwich Hospital Schools, by the Officers of that Establishment.

(Communicated by the Astronomer Royal.)

A short time since, the Admiralty placed in my hands a sheet of observations of the distances of the Comet II., 1861, from fixed stars, made by Commander A. L. Mansell, accompanied with the particulars which were absolutely necessary for their reduction, but with nothing tending to facilitate the reduction. At my request, the Rev. George Fisher most kindly took charge of the observations, and under his care they were reduced by the Officers of the Greenwich Hospital Schools.

The observations were made on board H.M.S. Firefly, her anchorage being within a quarter of a mile of the observatory-station used in the survey of Sidon, the position of which is—latitude $33^\circ 34' 26''$ N., longitude $35^\circ 21' 39''$ E. The latitude is determined from a mean of four meridian altitudes of α and β *Librae* south of the zenith, and ten observations of *Polaris*, using the *Nautical Almanac* method. The longitude is determined from three good meridian distances from Beirut, using eight chronometers; Beirut being fixed by a mean of seven meridian distances, using seven chronometers, run between it and Malta. The longitude of Malta is deduced from that of the Observatory at Palermo. [It will be remarked, in the subsequent computations, that a small error of latitude produces no error in the deduced place of the comet, except in so far as it alters the computed altitude of the star and comet, and therefore slightly alters the refraction and the correction of distance; and a small error of longitude produces no effect, except in the correction of distance for refraction, and in the computation of the comet's place from the Ephemeris.] Mean time was deter-

mined by equal altitudes of the Sun on the 2d and 8th of July. $\frac{210}{3063}$ is a good pocket-chronometer, by French: it has however always been compared with the standard chronometer (Dent, 1793), which watch shows a good mean of the nine chronometers.

The elements given are—the Greenwich mean time of each observation, and the observed distance, index-error, and corrected apparent distance.

It does not appear necessary to give all the numbers of the observations, or the troublesome reductions, but it may be proper to describe the method pursued:—

1. The Comet's R.A., N.P.D., and log. distance were interpolated from the Ephemeris published by M. Le Verrier in the *Bulletin*. The hour-angle being found, the true altitude was computed; and by calculation of refraction and parallax, the apparent altitude was found.

2. The Star's R.A. and N.P.D. being taken from the *Nautical Almanac*, its true altitude was computed, and by calculation of refraction the apparent altitude was found.

3. From the two apparent altitudes and the measured distance, with the corrections of altitudes, the true distance was found by the usual method of clearing Lunars.

4. The distances of the Comet from the two stars were measured at different times. But on each of the evenings the distance of the Comet from at least one star was measured twice; and the change of distance for a known interval being thus found, it was always possible to reduce to the same moment the measures of distance from two stars.

5. With the R.A. and N.P.D. of the two stars, the distance between them was soon found, and the angle made by that distance with the meridian of one star. The three sides of the triangle formed by the Comet and two stars being known, the angle at the star last mentioned was computed. Applying this angle to the angle just mentioned, the angle made by the Comet's distance with the star's meridian was found. The necessary elements for computing its diff. R.A. and its N.P.D. were thus completely obtained.

The following are the results for the Comet's place:—

Day.	G.M.T.			Comet's		Stars from which the Comet's Distance was measured.
	h	m	s	R.A. h m s	N.P.D. ° ' "	
1861. July 1	6	17	30	7 17 43.75	35 49 19.3	Polaris, Spica.
	6	21	13	7 17 54.55	35 45 24.7	Spica, α Coronæ.
	6	40	53	7 18 37.46	35 43 37.5	Polaris, Spica.
	6	42	25	7 18 43.80	35 39 39.4	Spica, α Coronæ.
2	6	6	17	8 17 30.55	28 40 28.4	Polaris, Spica.
	6	9	28	8 17 48.02	28 36 30.0	Spica, α Coronæ.
	8	52	33	8 25 7.69	28 3 56.1	Polaris, Spica.

Day. 1861.	G.M.T.			Comet's R.A.			N.P.D.			Stars from which the Comet's Distance was measured.
	h	m	s	h	m	s	°	'	"	
July 2	8	58	24	8	25	27.25	28	1	0.3	Spica, α Coronæ.
4	6	11	2	10	38	18.35	23	6	1.4	Spica, α Coronæ.
	6	15	19	10	37	49.00	23	9	9.7	Polaris, Spica.
5	7	44	33	11	39	5.43	23	32	3.8	Polaris, Arcturus.
	7	46	52	11	39	14.10	23	31	33.6	Arcturus, α Lyræ.
6	8	28	11	12	21	51.50	24	51	2.6	Polaris, Arcturus (not favourable).
	8	30	37	12	22	57.85	24	47	42.5	Arcturus, α Lyræ.
8	6	23	16	13	14	31.54	27	42	22.0	Polaris, Arcturus (unfavourable).
	6	29	40	13	14	43.99	27	42	38.1	Arcturus, α Lyræ.
9	6	32	26	13	31	43.01	29	9	5.8	Polaris, Arcturus (unfavourable).
	6	36	10	13	32	12.24	29	8	35.3	Arcturus, α Lyræ.
10	6	24	29	13	43	48.79	30	26	10.4	Polaris, Arcturus (unfavourable).
	6	28	28	13	45	33.27	30	24	20.3	Arcturus, α Lyræ.

November 4, 1861.

Places of Comet II. 1861. By N. M. R. Edmondson, Esq.,
Assistant, Armagh Observatory.

(Communicated by Dr. Robinson.)

G.M.T.	R.A.			Par. in R.A.	N.P.D.	Par. in N.P.D.
	h	m	s		°	'
July 1.4516	7	28	6.38	+ 0.0406	34	17 24.94 - 0.8468
2.5157	8	36	7 *		27	20 *
5.4739	11	46	52.63	0.0965	23	44 3.01 0.3383
6.4883	12	28	16.27	0.0908	25	18 19.22 0.3200
7.4954	12	57	27.90	0.0864	26	32 1.64 0.3088
9.4864	13	34	59.05	0.0755	29	25 58.07 0.2480
10.4464	13	47	43.69	0.0628	30	39 20.46 0.1304
14.4583	14	18	48.34	0.0570	34	36 52.47 0.1968
16.4787	14	27	38 *		36	5 *
18.4496	14	34	43.12	0.0515	37	13 3.49 0.2143
21.4722	14	42	27 *		38	34 *
23.4581	14	46	32.56	0.0520	39	26 16.47 0.2798

* Approximate.

18 *Mr. Hough, Observations made at Dudley Observatory.*

Comparison Stars.		Assumed Places.	Obs.
(1)	Federenko's Lalande 1166	Lalande	1
(2)	R.A. = $8^h 36^m 1^s$ *, N.P.D. = $27^\circ 14'$		2
(3)	Lalande 22785	ditto	4
(4)	Groombridge 1888	{ R.A. from Radcliffe N.P.D. from Armagh }	3
	„ 1926	Armagh Catalogue	4
	P. xiii. 110	ditto	4
	„ 233	ditto	5
	Groombridge 2102	ditto	5
	R.A. = $14^h 34^m 42^s$ *, N.P.D. = $36^\circ 0'$ *		3
	P. xiv. 164	ditto	5
	R.A. = $14^h 7^m 48^s$ *, N.P.D. = $38^\circ 33'$ *		1
	Radcliffe Catalogue	Radcliffe Catalogue	3

* Approximate.

Nov. 9th, 1861.

The Hydrographer of the Admiralty has communicated Observations taken by Mr. J. F. Krabbe, Master H. M. S. Meander, at Ascension Island, 1861, July 4, 8, and 29, of a Comet seen there, and which is, in fact, Comet II., 1861. The observations are sextant observations of the distances from three stars.

Sir Thomas Maclear, Director of the Royal Observatory at the Cape of Good Hope, has communicated to the Society a series of Right Ascensions and North Polar Distances of Comet III., 1860, deduced from observations made with the $8\frac{1}{2}$ -feet Equatoreal at the Observatory. The observations extend from 9 July to 18 Oct. 1860. The paper probably will appear *in extenso* in the *Memoirs* of the Society.

Observations made at the Dudley Observatory, Albany, New York. By G. N. Hough, Esq., Assistant.

(Communicated by Prof. O. M. Mitchell, Director of the Observatory.)

Observations of Comet II. 1861, made with the Equatoreal.

Date.	M.T. of Obs.	App. R.A.	App. Decl.
	^h ^m ^s	^h ^m ^s	[°] ['] ^{''}
Aug. 3	10 30 17.56	15 2 47.41	+47 29 14.87
10	10 54 35.16	15 10 38.48	
14	11 0 47.20	15 14 55.95	+45 34 20.17
15	9 57 45.91	15 15 57.44	

Aug. 3	Comp. *, 4961 Rumker	3 Comp.	
10	„ 15266, 15309 Arg.	5 „	
14	„ 15272, 15290 Arg.	7 „	Comet faint; moonlight
15	„ 15290 Arg.	6 „	Comet faint; moonlight

Occultation of 101 Piscium by the Moon.

1861, Aug. 24 11^h 26^m 31^s·0 Mean Time.

Disappearance instantaneous. Telescope (13 in.) Equatorial.

Observation of Minor Planets made with the Olcott Meridian Circle at the Dudley Observatory.

Calliope (28).

1861. Aug. 30	M.S.T. of Obs.	App. R.A.	App. Decl.
	h m s	h m s	° ' "
	12 13 55·49	22 51 23·25	
31	12 9 6·87	22 50 30·40	−30 23 24·79
Sept. 4	11 49 51·57	22 46 58·15	−30 28 33·21
9	11 25 49·98	22 42 35·38	−30 42 27·33
12	11 11 29·18	22 40 2·28	−30 48 58·88
13	11 6 45·26	22 39 13·74	−30 49 17·53

Themis (24).

1861. Aug. 31	M.S.T. of Obs.	App. R.A.	App. Decl.
	h m s	h m s	° ' "
	12 23 10·43	23 4 36·27	−6 55 42·58
Sept. 1	12 18 31·97	23 3 53·60	−7 0 2·65
4	12 4 35·23	23 1 44·23	−7 13 8·93
9	11 41 18·94	22 58 6·89	−7 34 52·85
12	11 27 22·48	22 55 57·79	−7 47 41·83
13	11 22 45·01	22 55 16·11	−7 51 47·38
24	10 32 11·52	22 47 56·40	−8 34 23·38

On a New Observing Clock. By Prof. C. Piazzi Smyth
Astronomer Royal for Scotland. (Abstract.)

The desideratum of obtaining a clock with an easily audible seconds' tick has been realised by Mr. R. L. Jones' patent method, to which Prof. Smyth was introduced by letters from Sir T. Maclear and Mr. Hartnup; and Mr. Jones himself procured a second-hand cast-iron barrel clock without striking parts, and having introduced into it his magnetic pendulum brought to the Edinburgh Observatory in April last, and

erected it in front of the transit instrument and in electric connexion with the old transit clock, removed for this purpose out of its former position and into the central hall of the Observatory.

The new observing clock goes as accurately as, because simultaneously with, the old transit or regulating clock, but with a vigour or mechanical power more than three hundred times greater, its driving weight being 180 lbs., descending 10 feet in one day, instead of 5 lbs., descending 3 feet in 7 days. The seconds' tick, though loud, was at first a peculiarly slumberous, heavy, and mournful sound, but this was remedied, as suggested by Mr. F. Ritchie, clockmaker in Edinburgh, by obtaining the seconds beat, not in the usual and almost invariable method by the escapement, but, by introducing for the purpose a tilt hammer striking on an anvil, the escapement being rendered noiseless, so as not to interfere with the note of the hammer. The most appropriate quality of sound was found to be produced by a steel hammer striking on an anvil of hard olive wood, hollowed out below, so as to be under one quarter of an inch thick. It would have been an advantage, as regards loudness, to have the hammer and anvil outside the case of the clock in the free open air of the room: this was not actually done, but the casing was taken in the form of a wooden tubing to them, and almost as loud a beat was obtained. The cost of the production of the electricity is trifling, and, as regards the first cost of the apparatus, Mr. Ritchie, having been recently applied to on the part of a Canadian Observatory, has estimated the cost of a big observing clock, with its hammer, anvil, and galvanic battery, at one-third to one-fourth part of the expense of a first-rate regulator or an ordinary astronomical transit. A collateral advantage has been found to be, that the old transit clock, as now locked up in a closet and used only to regulate the observing clock, remains in a more equable temperature.

Major A. Strange, late Astronomical Assistant in the Great Trigonometrical Survey of India, has sent to the Society three papers:—

“On Testing the Vertical Axes of Altazimuth Instruments.”

“On a Direct Method of Testing and Adjusting the Equipoise of Altazimuth Instruments.”

“On a proposed Isolated Flange for Conical Axes.”

It would be useless to attempt giving an abstract of these elaborate papers, relating, as they do, to instrumental details, and requiring the illustration of a series of figures.

Information has been received of the death of M. Daussy, Member of the Bureau des Longitudes at Paris, and an Associate of the Society.

RECENT PUBLICATIONS.

Astronomical Observations made at the Sydney Observatory in the year 1859. By W. Scott, M.A., Astronomer for New South Wales. Sydney, 1860. 8vo. pp. i. to xxiv. and 1 to 112.

In the *Monthly Notices*, vol. xix. p. 293, are printed some extracts from the first Annual Report to the Observatory Board, 22d Dec. 1858, giving an account of the establishment and the position of the Observatory. The Transit Circle arrived from England about the end of December 1858; but the regular observations were not commenced until June 1859.

It appears by the observations published in the *Monthly Notices*, vol. xx. p. 77, that the latitude and longitude of the Observatory were provisionally found to be Lat. $33^{\circ} 51' 41''.1$ S.; Long. $10^{\circ} 4' 59''.86$ W. The corrected values, as given by the Observations of Zenith Distances of *Nautical Almanac* Stars and the Observations of Moon-culminating Stars during the year 1859, are found to be Lat. $33^{\circ} 51' 40''.8$ N.; Long. $10^{\circ} 4' 59''.96$ W.

The greater part of the volume is occupied with Transit and Zenith-distance Observations of Stars; and from these are deduced the mean right ascensions and north polar distances for 1st January, 1859. It is from the internal evidence afforded by these that an estimate can be formed of the amount of reliance to be placed on the results which may hereafter proceed from the Observatory.

The causes of error are in a great measure of a temporary nature; such, for instance, as the changes in the piers of the instrument, owing to the contraction of the sandstone; but the results indicate also a permanent instrumental error, such as an irregularity in the form of the pivots. The errors of observation are not greater than those which occur in observatories of a high class, as those at Oxford and Cambridge, and are such as to disappear to a great extent when the mean of four or five observations is taken; but the instrumental errors are such that, although the circle may be regarded for some purposes as a useful instrument, yet it cannot be classed among instruments of the highest order, nor can its results compare in accuracy with those obtained at the Royal Observatory at the Cape of

Good Hope. It was therefore desirable to avoid as much as possible observing the same stars as had recently been, or would soon be observed, at the Cape of Good Hope. But, in the absence of information from thence, it was decided to observe, in addition to *Nautical Almanac* stars, only those stars of the 6th and 7th magnitudes which are given in the British Association Catalogue or in Lacaille's New Catalogue; and up to the end of 1859 the observations were limited to a space of 10° on each side of the zenith. But the equatoreal telescope, which has been ordered of Messrs. Merz and Son (7 inches French in aperture and 9 feet 8 inches focal length), and is in course of construction, when it arrives, may perhaps give a totally different direction to the efforts of the Observatory.

Taschenbuch für Mathematik, Physik, Geodäsie, und Astronomie. Von Dr. Rudolf Wolf, dritte umgearbeitete und erweiterte mit 22 Tabellen und 5 Figurentafeln ausgestattete Auflage, 12mo. Bern, 1860, pp. 1-269.

This little volume appears to be a most convenient handbook, comprising the utmost possible information for its bulk on the subjects to which it relates, and the author's name is a guarantee for the character of the work.

Memoria sobre el Eclipse de Sol de 18 de Julio de 1860.

Por D. Francisco de Paula Marquez, Capitan de Navio de la Armada, y Director del Observatorio de Marina de S. Fernando. Publicada de Orden Superior. 8vo. Madrid, 1861.

The work contains an account of the Observations of the Eclipse, made at Oropesa, on the east coast of Spain, near the central line, by the Spanish Naval Commission under the command of D. F. Marquez, in company with the Portuguese Commission from Coimbra. It contains also an elaborate "Optical" theory of the Corona, Red Prominences, and other phenomena of the Eclipse, considered as arising from the diffraction and reflexion in our atmosphere of the light refracted at the border of the Moon's disk, and from the motion of the Moon.

Beobachtung der totalen Sonnen-Finsterniss vom 18 (6) Juli, 1860, in Pöbes. Nach den Berichten der einzelnen Theilnehmer zusammengestellt von Otto Struve. Mit 3 Tafeln. (From the *Mém. de l'Acad. de St. Pétr.* t. iv. 1861.)

The party from Pulkova who joined the Himalaya Expedition consisted of M. O. Struve, Dr. Winnecke, and the Portuguese Astronomer, Lieut. Oom, and the memoir contains an account of the observations of the Astronomer Royal, the three Pulkova Astronomers, and Herr C. Weiler, at or near Pöbes, and of Herr Stenglein at Lodio, a few miles south of Bilbao.

Mémoire sur l'intégration des Equations différentielles relatives au Mouvement des Comètes, établies suivant l'hypothèse de la force répulsive définie par M. Faye, et suivant l'hypothèse d'un Milieu résistant dans l'espace. Par Jean Plana. (*Turin Memoirs*, t. xxi. 1861.)

This memoir, dated 12 Sept. 1861, replaces one with the same title presented to the Turin Academy, 26 May, 1861, the numerical results of which were erroneous, in consequence of an error of transcription in one of the formulæ. The conclusion arrived at is stated to be, that while the hypothesis of M. Faye gives results approaching those observed for the two periodic comets of 1205 days and 2718 days (Encke's and Faye's), a better agreement with the results of observation is obtained by the hypothesis of a resisting medium. The investigation relates exclusively to the motion of the centre of gravity of the comet.

M. Faye's hypothesis, referred to in his paper, *Comptes Rendus*, 4 March, 1861, consists in supposing that there is a repulsive force emanating from the incandescent surface of the Sun, and, like the attractive force, varying as the inverse square of the distance, but which, in consequence of the finite velocity of propagation, acts in a direction inclined to that of the radius vector.

Tabulæ Quantitatum Besselianarum quibus Apparentes Stellarum Positiones in Medias convertuntur, adhibitis Numeris Constantibus Pulcovensibus pro annis 1840 ad 1864 computatæ. Ed. O. Struve. 8vo. Pet. 1861.

The tables are based on the formulæ and numerical values of the constants of precession, nutation, and aberration, given

in Peters' well-known work, *Numerus Constans Nutationis*, &c., Pet. 1842.

They contain for the 25 years to which they relate the logarithms of the quantities A, B, C, D, and the quantity τ for 0^h Pulkova sidereal time of each day. The quantity E, which varies very slowly, is given only for the last day of each month. Besides the logarithms of A, B, C, D, there are given, in the cases where the rapid variation of the logarithms renders it necessary for accuracy, the natural values of B, C, D.

Arc du Meridian de 25° 20' entre la Danube et la Mer Glaciale, mesuré depuis 1816 jusqu'en 1855. Sous la direction de C. de Tenner, Général d'Infanterie de l'Etat-Major Impérial de Russie, Chr. Hansteen, Directeur du Departement Géographique Royal de Norvège, N. H. Selander, Directeur de l'Observatoire Royal de Stockholm, et F. G. W. Struve, Directeur de l'Observatoire-Central-Nicolas de Russie. Ouvrage composé sur les différens Matériaux et rédigé par F. G. W. Struve. Publié par l'Académie des Sciences en St. Pétersbourg. Tome premier, Opérations géodésiques entre le Danube et le Golfe de Finlande, St. Pét. 1860. Tome deuxième, Opérations Géodésiques entre le Golfe de Finlande et la Mer Glaciale. St. Pét. 1857. Deux volumes, 4to. avec Atlas de 26 planches.

The introduction to vol. i. contains the general history of this great geodetical undertaking. The total arc, comprised between Fuglencas, lat. 70° 40' (near the North Cape), and Staro-Nekrassowka, lat. 45° 20' (near the mouth of the Danube), is 25° 20' in latitude. It is composed of 258 principal triangles, with 10 measured bases, not reckoning among the 258 triangles the triangles which effectuate the junction of the bases with the chain of triangles. The distance between the extreme points, measured on the great circle joining them, is 2700 versts = 2880 kilometers = 1552 geographical miles. The Observatory of Dorpat is about half-way between the extreme points, and may be considered as the meridian of the total arc.

The total arc is divided into two principal portions, a southern and a northern arc, meeting at the Island of Hogland in the Gulf of Finland; in fact, the triangles of the two arcs form two distinct series, having a common point at Mäki-Päällys in Hogland, but without any common side connecting the terminal triangles of the two arcs.

There are on the total arc 13 points where the azimuth and latitude have been astronomically determined. The Observatory of Dorpat is the only point the longitude whereof

has been determined with eminent precision, by the chronometric comparison in the year 1854, between Dorpat and Pulkova.

In a statistic and chronological point of view, disregarding the observations of latitude which were in part repeated at a posterior epoch; the total arc may be divided into seven parts, which are

Arc of	Between Latitudes.	Measured under direction of	In the Years
1. Bessarabia	$45^{\circ} 20' - 48^{\circ} 15'$	M. de Tenner	1844-1852
2. Podolia and Volhynia	$48^{\circ} 15' - 52^{\circ} 3'$	ditto	1835-1840
3. Lithuania	$52^{\circ} 3' - 56^{\circ} 30'$	ditto	1816-1828
4. Baltic Provinces	$56^{\circ} 30' - 60^{\circ} 5'$	M. Struve	1816-1831
5. Finland	$60^{\circ} 5' - 65^{\circ} 50'$	ditto	1830-1851
6. Lapland	$65^{\circ} 50' - 68^{\circ} 54'$	M. Selander	1845-1852
7. Finmark	$68^{\circ} 54' - 70^{\circ} 40'$	M. Hansteen	1845-1850

and the history may be divided into four periods, embracing
1. The origin of the undertaking, and the operations of MM. de Tenner and Struve relating to the arcs of Lithuania and the Baltic Provinces, united into a single arc of $8^{\circ} 2'$. The period terminates in 1831.

2. The period 1830 to 1844 comprises the continuation of the meridian northwards to Tornea, latitude $65^{\circ} 50'$, and the preparations for the Southern continuation as far as the Dniester.

3. From 1844 to the end of the year 1851, comprising the continuation southwards to the Danube and northwards to the Arctic Ocean.

4. The supplementary operation posterior in date to 1851, intended partly to reduce to uniformity and a higher degree of perfection the data requisite, as well for the union of the different partial arcs, as for the utilisation of this arc for the determination of the figure of the Earth.

There is given, pp. cxli. to cxliii., a chronological catalogue of the different publications in the *Astronomische Nachrichten*, the *Memoirs* and *Bulletins of the Academy of St. Petersburg* and elsewhere, in relation to the measurement of the arc of $25^{\circ} 20'$.

The astronomically determined latitudes in the Russian-Scandinavian Arc of $25^{\circ} 40'$ are not, as in the English Ordnance Trigonometrical Survey, corrected for the deviations of the plumb-line due to the calculated attractions of the ine-

qualities of the surface in the neighbourhood of the Station. It appears that in the opinion of General de Schubert, this correction should have been made; and with a view thereto, there should be a careful levelling of all the astronomical stations, or at least of certain specified astronomical stations, on the arc. The question is discussed by M. Otto Struve in a paper in the *Bulletins of the Academy of St. Petersburg* ($\frac{8}{20}$ Feb. 1861), in which he maintains the contrary opinion, that this correction ought not to be made.

Astronomical Observations made at the Observatory of Cambridge. By the Rev. James Challis, M.A. &c. Vol. xix. for the years 1852, 1853, and 1854. 4to. Camb. 1861.

The volume contains the Observations made with the Transit and Mural Circle in the years 1852, 1853, and 1854, the Observations of Planets and Comets with the Northumberland Equatoreal in the same interval being reserved for separate publication with those of preceding years.

The major part of the observations of the three years are directed towards the determination of the places of stars, and more especially such as are included in the list of 8000 zodiacal stars, observations of which were commenced in 1849.

The observations of the Moon and Moon-culminating Stars were discontinued at the end of 1852. The Sun, the Planet *Neptune*, and the Minor Planets, were observed in that and the two following years. All these observations were compared calculated places, and if no Ephemeris was available for the purpose, the places were directly computed from elements of the orbits.

Astronomical and Meteorological Observations made at the Radcliffe Observatory in the year 1858. Under the Superintendence of Manuel J. Johnson, M.A., late Radcliffe Observer. Reduced and Printed under the Superintendence of the Rev. R. Main, M.A., Radcliffe Observer. Vol. xix. Published by order of the Radcliffe Trustees. 8vo. Oxford, 1861.

Instruments for Sale.

The Radcliffe Observer is empowered to offer for sale the Transit Instrument and Meridian Circle which have been in use since the commencement of Mr. Johnson's directorship till the present time, but which are now unnecessary on the establishment of the Carrington Transit Circle.

The Transit Instrument has an object-glass of 4 inches clear aperture, with a focal length of 8 feet, and is an excellent instrument of its class. Price 120*l.* without the piers.

The Meridian Circle, by Jones, is 6 feet in diameter, and its telescope, of the same focal length, has a clear aperture of 4 inches. It cost about 1000*l.* Price without its piers 300*l.*

The piers may be taken at a valuation at the discretion of the purchaser.

The Astronomer Royal has been requested by the Rev. George Fisher to state that Commander Mansell's Comet observations (see page 16) were computed by the senior boys of the Nautical School, under the direction of John Riddle, Esq., Head Master of the Nautical School.

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MONTHLY NOTICES
OF THE
ROYAL ASTRONOMICAL SOCIETY.

VOL. XXII.

Dec. 13, 1861.

No. 2.

Dr. LEE, President, in the Chair.

Henry Worms, Esq., Park Crescent, Portland Place; and
Rev. John Sargent, 6 Bentinck Terrace, Regent's Park,
were balloted for and duly elected Fellows of the Society.

Grant for a Hill Observatory in India.

The following letter was received in answer to an application for the aid of Her Majesty's Government towards the establishment for a limited period, under the superintendence of Captain Jacob, of an Observatory in the neighbourhood of Bombay, at a considerable altitude above the sea.

*Treasury Chambers,
8th August, 1861.*

In reply to your application addressed to Lord Palmerston on the 24th June last, for a grant to the Royal Astronomical Society of 1000*l.* in aid of the proposed temporary maintenance of an observatory near Poonah, I am commanded by the Lords Commissioners of Her Majesty's Treasury to acquaint you that the sum of 1000*l.* having been voted in Parliament for the object described in your letter, My Lords will be prepared to issue the

amount in such manner as you may desire, on the understanding that the Society will see to the proper application of the fund thus placed at its disposal.

I have the honour to be, Gentlemen.

Your obedient servant,

(Signed) GEO. A. HAMILTON.

*The President and Treasurer of the Royal Astronomical Society,
Somerset House.*

A letter was sent to his Lordship expressing the thanks of the Council for the promptness with which their application had been met.

The foregoing grant was announced by the President at the November Meeting, and should have been mentioned in the last number of the *Notices*.

On the Right Ascensions and Declinations of the Radcliffe Catalogue. By Dr. Wolfers.

(Communicated by the Rev. R. Main.)

The Radcliffe Trustees having presented to me the observations made at the Radcliffe Observatory, Oxford, vols. xviii. and xix., I have compared the places of stars contained in these two volumes with those contained in the *Tabulæ Reductionum*. Having combined these two series of differences with the earlier-obtained series (*Astr. Nachr.*, No. 1181), I have obtained the table of comparisons which I now send.

Excluding only the R.A. of the two polar stars α and δ *Ursæ Minoris*, the result of the comparison is

J. — W.			
Number of Observations.	R.A.	Number of Observations.	Decl.
347	+ 0° 026	288	+ 0° 046

Excluding, moreover, the R.A. of the circumpolar stars α *Ursæ Majoris*, γ *Ursæ Majoris*, and β *Ursæ Minoris*; further excluding the R.A. of α *Geminorum*, because in the *Tab. Red.* there is given the mean of the R.A. of α^1 and α^2 *Geminorum*, but in the observations the R.A. of each of them, the difference of the two R.A. given in the *Astr. Jahrbuch* being not very accurate, the result of the whole comparison is

J. — W.			
Number of Observations.	R.A.	Number of Observations.	Decl.
326	+ 0° 017	288	+ 0° 046

To the R.A. of α *Canis Majoris* the correction of M. Peters is applied; and these differences being reduced to the year 1860,

Declinations of the Radcliffe Catalogue.

31

J. denotes the co-ordinates observed at Oxford, W. denotes the co-ordinates given in the *Tab. Red.*

The Right Ascensions and Declinations of Fundamental Stars observed at the Radcliffe Observatory, compared with those contained in the Tabulae Reductionum.

Name of Star.	Number of Observations.	J.—W. R. A.	Number of Observations.	J.—W. Decl.
α Andromedæ ...	4	+0°02	5	+0°7
γ Pegasi ...	9	—0°04	6	+2°6
α Cassiopeiæ ...	3	+0°09	4	—0°4
α Arietis ...	6	—0°02	3	+1°5
α Ceti ...	9	+0°01	4	+0°4
α Persei ...	5	—0°06	3	—0°2
α Tauri ...	16	—0°02	9	+0°2
α Aurigæ ...	5	—0°01	6	—0°6
β Orionis ...	8	0°00	7	+0°4
β Tauri ...	5	+0°05	6	+2°5
α Orionis ...	8	+0°02	5	+1°4
α Canis Majoris...	8	—0°02	20	—0°4
α Geminorum ...	10	+0°12	8	+1°8
α Canis Minoris...	11	+0°03	9	+0°6
β Geminorum ...	16	—0°01	10	+0°3
α Hydræ... ..	9	+0°06	7	—2°1
α Leonis... ..	15	+0°01	12	+1°1
α Ursæ Majoris...	5	+0°32	12	+0°6
β Leonis... ..	9	+0°08	6	—0°3
β Virginis ...	9	+0°13	5	—0°4
γ Ursæ Majoris...	5	+0°21	2	+0°2
α Virginis ...	12	+0°08	14	—1°3
α Ursæ Majoris...	10	+0°06	2	—0°8
α Bëotis ...	6	+0°02	2	+0°4
α^1 Libræ... ..	1	+0°04	4	—0°4
α^2 Libræ... ..	10	+0°10	3	—0°6
β Ursæ Minoris...	1	—0°26	5	—0°1
α Coronæ ...	9	+0°01	3	—0°7
α Serpentis ...	10	0°00	3	—0°4
α Scorpii... ..	12	+0°14	7	—0°2
α Herculis ...	6	—0°10	1	—0°2
α Ophiuchi ...	10	—0°02	8	—0°1
γ Draconis ...	5	+0°03	4	—0°8
α Lyræ ...	11	+0°07	3	—0°4
γ Aquilæ... ..	6	0°00	3	—0°7

Name of Star.	Number of Observations.	J. — W. E. A.	Number of Observations.	J. — W. Decl.
α Aquilæ ...	10	-0°05	9	+0°3
β Aquilæ ...	4	+0°02	4	-0°2
α^1 Capricorni ...	—	—	2	-1°8
α^1 Capricorni ...	5	+0°01	5	-2°8
α Cygni ...	8	-0°01	6	-2°4
α Cephei... ..	11	-0°07	7	+0°9
β Cephei... ..	4	-0°11	10	+0°2
α Aquarii ...	9	-0°06	2	-1°0
α Piscis Australis	8	-0°02	8	-0°4
α Pegasi	4	-0°12	6	-0°3
α Ursæ Minoris...	8	-0°24	4	0°0
δ Ursæ Minoris...	4	+0°48	9	+1°8

Berlin, November 30, 1861.

On the Secular Acceleration of the Moon's Mean Motion.
By A. Cayley, Esq. (Abstract.)

The inclination and excentricity of the Moon's orbit, and *a fortiori* the variation of the position of the ecliptic, and the latitude of the Sun, are neglected; and the longitudes are measured from a fixed point in the ecliptic. The notation is in the present Abstract explained in so far only as it presents any peculiarity. I take

n , the actual mean motion of the Moon at a given epoch;

viz., it is assumed that the mean longitude at the time t is $s + n t + n_1 t^2 + \&c.$ where s , n , n_1 , &c. are absolute constants; and, moreover,

a , the calculated mean distance of the Moon;

that is, $n^3 a^3$ is the sum of the masses of the Earth and Moon;
 a is, therefore, an absolute constant.

$m = \frac{n'}{n}$, is an absolute constant.

The Sun is considered as moving according to the law of elliptic motion in an orbit the excentricity whereof is $e' + \delta e'$, or $e' + f' t$, where e' , f' , are absolute constants.

In the expression of the disturbing function the Sun's mass is taken to be $= n^2 a^3$, or, what is the same thing, $= m^2 n^2 a^3$.

Then r , v , being the radius vector and longitude of the Moon, and taking the usual approximate expression of the disturbing function, the equations of motion are

$$\frac{d}{dt} \frac{dr}{dt} - r \left(\frac{dv}{dt} \right)^2 + \frac{n^2 a^3}{r^3} = m^2 n^2 a^3 \frac{r}{r^3} \left(\frac{1}{2} + \frac{3}{2} \cos 2v - 2v' \right),$$

$$\frac{d}{dt} \frac{r^2 dv}{dt} = m^2 n^2 a^3 \frac{r^2}{r^3} \left(-\frac{3}{2} \sin 2v - 2v' \right);$$

or writing

$$\frac{r}{a} = \epsilon, \quad \frac{r'}{a} = \epsilon',$$

we have

$$\frac{d}{dt} \frac{\partial \epsilon}{dt} - \epsilon \left(\frac{dv}{dt} \right)^2 + \frac{n^2}{\epsilon^3} = m^2 n^2 P,$$

$$\frac{d}{dt} \left(\epsilon^2 \frac{dv}{dt} \right) = m^2 n^2 Q,$$

where, for shortness,

$$P = \frac{\epsilon}{\epsilon^3} \left(\frac{1}{2} + \frac{3}{2} \cos 2v - 2v' \right),$$

$$Q = \frac{\epsilon^2}{\epsilon^3} \left(-\frac{3}{2} \sin 2v - 2v' \right).$$

The notation is then changed by writing $\epsilon' + \delta \epsilon$, $v' + \delta v$, in the place of ϵ , v ; using henceforward ϵ' , v' , to denote the elliptic values of the solar co-ordinates, as calculated with the constant excentricity ϵ' ; and, moreover, $\epsilon + \delta \epsilon$, $v + \delta v$, in the place of ϵ , v ; using henceforward ϵ , v , to denote the values of the lunar co-ordinates obtained from the equations of motion by writing therein ϵ' , v' , instead of the complete values $\epsilon' + \delta \epsilon$, $v' + \delta v$. Then putting

$$\delta P = \frac{dP}{d\epsilon} \delta \epsilon + \frac{dP}{dv} \delta v + \frac{dP}{d\epsilon'} \delta \epsilon' + \frac{dP}{dv'} \delta v',$$

with a like value for δQ , and observing that the equations of motion are satisfied when $\delta \epsilon$, δv , $\delta \epsilon'$, $\delta v'$, are neglected, we have

$$\frac{d}{dt} \frac{d\delta \epsilon}{dt} - \delta \epsilon \left(\frac{dv}{dt} \right)^2 - 2\epsilon \frac{dv}{dt} \frac{d\delta v}{dt} - \frac{2n^2}{\epsilon^3} \delta \epsilon = m^2 n^2 \delta P,$$

$$\frac{d}{dt} \left(\epsilon^2 \frac{d\delta v}{dt} + 2\epsilon \delta \epsilon \frac{dv}{dt} \right) = m^2 n^2 \delta Q;$$

or, integrating the second equation, and by means of such integral changing the form of the first equation, we have

$$\frac{d^2 \delta \epsilon}{dt^2} + n^2 \delta \epsilon = \left\{ n^2 + \frac{2n^2}{\epsilon^2} - 3 \left(\frac{dv}{dt} \right)^2 \right\} \delta \epsilon + m^2 n^2 \left\{ \delta P + \frac{2}{\epsilon} \frac{dv}{dt} \left(C + \int \delta Q dt \right) \right\},$$

$$\frac{d \delta v}{dt} = - \frac{2}{\epsilon} \frac{dv}{dt} \delta \epsilon + \frac{m^2 n^2}{\epsilon^2} \left(C + \int \delta Q dt \right),$$

where C is to be determined by the condition that $\frac{d \delta v}{dt}$ may contain no constant term (for otherwise nt would not be the whole term varying directly as the time, in the longitude $v + \delta v$). The values of ϵ' , v' , $\delta \epsilon'$, $\delta v'$, are given by the theory of elliptic motion, and those of ϵ , v , by the ordinary lunar theory, in which the excentricity of the solar orbit is treated as a constant; the integration of the last-mentioned equations leads to the values of $\delta \epsilon$, δv , and then the radius vector and longitude of the moon are $a(\epsilon + \delta \epsilon)$, $v + \delta v$, respectively.

We, in fact, have

$$\begin{aligned} \frac{1}{\epsilon} &= 1 + \frac{1}{6} m^2 \\ &+ \frac{3}{2} m^2 \epsilon' \cos g' \\ &+ m^2 \quad \quad \quad ,, \quad 2\tau \\ &+ \frac{7}{2} m^2 \epsilon' \quad \quad ,, \quad 2\tau - g' \\ &- \frac{1}{2} m^2 \epsilon' \quad \quad ,, \quad 2\tau + g' \\ v &= nt + i \\ &- 3 m \epsilon' \sin g' \\ &+ \frac{11}{8} m^2 \quad \quad \quad ,, \quad 2\tau \\ &+ \frac{77}{16} m^2 \epsilon' \quad \quad ,, \quad 2\tau - g' \\ &- \frac{11}{8} m^2 \epsilon' \quad \quad ,, \quad 2\tau + g' \end{aligned}$$

$$(g' = c' m n t + \text{const.} \quad 2\tau = (2 - 2m) n t + \text{const.})$$

$$\begin{aligned}
\frac{1}{\epsilon} &= 1 \\
&+ e' \cos g' \\
v' &= n' t + 1 \\
&+ 2 e' \sin g' \\
\delta \frac{1}{\epsilon} &= 1 \quad t \cos g' \\
&+ 2 e' \quad ,, \quad 2 g' \\
\delta v' &= 2 \quad t \sin g' \\
&+ \frac{5}{2} e' \quad ,, \quad 2 g'
\end{aligned}$$

where, instead of $\delta e' = f' t$, $\delta e'$ has been put $= t$, a simplification which is employed throughout the working, the factor f' being restored in the final results.

The values in the first instance obtained for δe , δv , are

$\delta e = f'$ into as follows, viz. :

$$\begin{aligned}
&\frac{3}{2} m^2 e' t && + \overbrace{3 m^3 \sin g'}^{n-1 \times} \\
+ \frac{3}{2} m^2 t \cos g' &&& 3 m^3 \sin g' \\
+ 5 m^2 e' \quad ,, \quad 2 e' &&& - \frac{203}{12} m^3 e' \quad ,, \quad 2 e' \\
- \frac{7}{2} m^2 \quad ,, \quad 2 e' - g' &&& + \frac{61}{24} m^2 \quad ,, \quad 2 e' - g' \\
+ \frac{1}{2} m^2 \quad ,, \quad 2 e' + g' &&& - \frac{91}{14} m^2 \quad ,, \quad 2 e' + g' \\
+ \frac{9}{2} m^2 e' \quad ,, \quad 2 g' &&& - 18 m^3 e' \quad ,, \quad 2 g' \\
- 17 m^2 e' \quad ,, \quad 2 e' - 2 g' &&& + \frac{85}{6} m^2 e' \quad ,, \quad 2 e' - 2 g' \\
0 \quad ,, \quad 2 e' + 2 g' &&& - \frac{3}{4} m^2 e' \quad ,, \quad 2 e' + 2 g'
\end{aligned}$$

and

$\delta v = f'$ into as follows, viz. :

$$\begin{aligned}
& - \frac{3}{2} m^2 n e' t^2 \\
& - 3 t \sin g' && + \overbrace{- 3 + 6 m^3 \cos g'}^{n-1 \times}
\end{aligned}$$

$$\begin{aligned}
 & -\frac{55}{8} m^2 e' \sin 2\tau & -\frac{74}{3} m^2 e' \cos 2\tau \\
 & +\frac{77}{16} m^2 \quad ,, \quad 2\tau - g' & +\frac{215}{48} m^2 \quad ,, \quad 2\tau - g' \\
 & -\frac{11}{16} m^2 \quad ,, \quad 2\tau + g' & -\frac{257}{48} m^2 \quad ,, \quad 2\tau + g' \\
 & -\frac{9}{2} m e' \quad ,, \quad 2g' & \left(-\frac{9}{4} + 18 m^2\right) e' \quad ,, \quad 2g' \\
 & +\frac{187}{8} m^2 e' \quad ,, \quad 2\tau - 2g' & +\frac{2239}{96} m^2 e' \quad ,, \quad 2\tau - 2g' \\
 & 0 \quad ,, \quad 2\tau + 2g' & -\frac{33}{32} m^2 e' \quad ,, \quad 2\tau + 2g'
 \end{aligned}$$

where it is to be noticed that the terms $t \cos \arg.$ and $t \sin \arg.$ arise from the substitution of $e' + f' t$ for e' in the coefficients of the terms $\cos \arg.$ and $\sin \arg.$ in the ordinary values of ϵ and v . The new periodic terms $\sin \arg.$ in $\delta \epsilon$ and $\cos \arg.$ in δv agree as to the arguments $g', 2\tau, 2\tau - g', 2\tau + g'$, with those obtained by Prof. Adams; those for the other arguments $2g', 2\tau - 2g', 2\tau + 2g'$, do not contribute to the formation of the term in m^4 of the acceleration.

Starting from the foregoing expressions of $\delta \epsilon$ and δv , and proceeding to calculate the non-periodic parts as far as m^4 , the results are found to be

$$\delta \epsilon = \left(\frac{3}{2} m^2 - \frac{1973}{32} m^4 \right) e' f' t,$$

where the number $\frac{1973}{32}$ is made up

$$-\frac{1973}{32} = \frac{381}{8} - \frac{495}{32} - \frac{15}{4} - \frac{647}{32} - \frac{1455}{16} + \frac{675}{32};$$

and

$$\delta v = \left(-\frac{3}{2} m^2 + \frac{3771}{64} m^4 \right) e' f' t^2,$$

where the number $\frac{3771}{64}$ is obtained by means of the before-mentioned number $\frac{1993}{32}$; but replacing this number $\frac{1973}{32}$ by its component terms, the number $\frac{3771}{64}$ is made up

$$\frac{3771}{64} = -\frac{381}{8} + \frac{495}{32} + \frac{15}{4} + \frac{647}{32} + \frac{1455}{16} - \frac{675}{32} + \frac{275}{16} + \frac{45}{16} - \frac{1455}{64}.$$

It is hardly necessary to remark that, f'^2 being neglected, $2 e' f' t = (e' + f' t)^2 - e'^2$, and $\therefore e' f' t^2 = \int [(e' + f' t)^2 - e'^2] dt$, where $(e' + f' t)^2 - e'^2$ is what is commonly represented by $(e'^2 - E'^2)$. The value of m is not that made use of by Prof. Adams; in fact,—

$$m \text{ (Adams)} = m \left\{ 1 + \left(\frac{3}{2} m^2 - \frac{3771}{64} m^4 \right) 2 e' f' t \right\}$$

but in the terms multiplied by f' the two values of m may be considered as identical, hence the foregoing expression of δv , in the notation of Prof. Adams, is

$$\delta v = \left(-\frac{3}{2} m^2 + \frac{3771}{64} m^4 \right) \int (e'^2 - E'^2) n dt$$

the result obtained by him. The number $\frac{1973}{32}$, the coefficient of m^4 in the expression δe , does not occur explicitly in his memoir, but is, in fact, deducible from the value there given for the reciprocal of the radius vector. The present abstract gives a complete outline of the method of investigation, and it was thought better to omit altogether the details of the working rather than present them in an incomplete manner.

The Transit of Mercury, Nov. 11, 1861.

(Extract of a Letter from Father Secchi to the Astronomer Royal, dated Rome, Nov. 16, 1861.)

The passage of *Mercury* on the solar disk has been observed here under very good circumstances, but almost by a miracle, because the sky was all overcast by clouds. Some details will be found in the *Comptes Rendus*, and more yet in the *Astronomische Nachrichten*. But it will not displease the Astronomical Society to know the principal results; they are the following:—

Interior contact, Sid. T. Rome ...	^h 13	^m 35	^s 6.29
Or M.T. Rome	22	9	9.45
Centre (estimated), Sid. T.	13	36	10.19
Exterior contact, Sid. T.	13	37	14.09

The air was exceedingly calm, and the rupture of the narrow ring was made with the utmost tranquillity, leaving two very sharp cusps. The exterior edge of the Sun appeared in the narrow thread of light, before the rupture, more faint

a good deal than the part of the Sun at the opposite point of the diameter of the planet. The blackness of the planet appeared greater a good deal than the usual nuclei of the spots, and its termination persuaded me that the nuclei are really badly terminated, and that there is a real diffusion of matter in their borders. In the intervals left between the clouds, during the passage, I measured a great many distances and positions of the planet from the edge of the Sun's disk; and I made, also, 9 double measures of the diameter of the planet. The result of these is $=9''.077$, with probable error $=0''.189$. It is remarkable that the duration of the passage gives for this diameter $9''.165$. This value is different from that given in the tables. A year ago I obtained from some measures a diameter even smaller—that is, $8''.91$. I propose to take a few more measures of this element; but it is rather difficult, on account of the termination of *Mercury's* disk, which is always very bad, and seems to be very faint at the edges.

A new discussion of my magnetical observations compared with a series of electrical atmospherical observations have led me to admit a real connexion between this electricity, and the variations of at least the horizontal intensity. In many things, I think, M. Lamont is right; and what he has suggested on this account I believe him to have demonstrated and seen directly.

The Transit of Mercury, November 11, 1861, observed at Malta. By W. Lassell, Esq.

At No. 9, Piazza Stierna, Via Torre, Malta, approximate longitude $58^m 2^s$ east of Greenwich, latitude $35^{\circ} 54' 46''$ north, 1861, Nov. 11th, I observed the emersion, or egress, and part of the transit of *Mercury* over the Sun. The best telescope I had at hand was a very sharply-defining Gregorian of 4.7 inches aperture; power used, 78. I first pointed the telescope at about 19.50 Stierna mean time. The planet, being considerably advanced on the disk, appeared perfectly well defined, round, and black. I watched the phenomenon from time to time until about 22^h; after which I observed it uninterruptedly until its disappearance. I had, however, no means suitable for making any accurate measures; but I was filled with admiration, throughout, of the exquisite beauty of the vision. The limb of the Sun and the disk of the planet were far more sharp and beautiful than I have ever seen them with equal power, and within $1\frac{1}{2}$ to 3 hours of the horizon.

Notwithstanding that the heat of the Sun was so great as to make a shield necessary for the exposed part of my person (though I was generally well protected by a verandah), yet the image was, with occasional slight disturbances, as sharp as can be conceived, and afforded a striking contrast to all I have seen before.

I scrutinised the planet well throughout its transit, but could not be sure of any peculiarity. I repeatedly *fancied* it a little elliptical, but I do not believe in the reality of the appearance.

The times are given in Stierna mean time; they were noted with a duplex watch, compared with a standard mean time clock, accurately corrected and rated by sextant observations.

At 22^h 15^m 57^s.1 the planet was estimated to be just its own diameter from the Sun's limb.

At 22^h 16^m 13^s.5 it was clearly within one diameter.

At 22^h 18^m 5^s.9, first contact. Shortly after, the planet seemed momentarily drawn out towards the limb, pear-like.

At 22^h 18^m 53^s.5 the Sun's limb bisected the planet. No distortion whatever. Shortly afterwards I had a momentary impression of the lengthening out of the diameter which was a tangent to the Sun's limb, or which had just passed it.

At 22^h 20^m 21^s.5, last contact, *i. e.* the first moment that I was sure that the planet was no more to be seen.

It has rarely been my lot to observe an astronomical phenomenon with circumstances so favourable and pleasant.

I have much pleasure in stating that I have erected the 4-foot equatoreal telescope on a very excellent site, across the Quarantine Harbour from Valetta, and nearly north of it, within a short distance of Fort Tigné.

A boundary wall, inclosing an area twenty yards square, in the centre of which the telescope stands, and a sufficiently capacious laboratory adjacent, are on the point of completion. The observing tower is in process of erection, and I hope very shortly to commence operations.

*Observations of the Transit of Mercury, November 11, 1861,
made at the Observatory, Durham. By Prof. T. Chevallier.*

The weather was very favourable, at Durham, for observing the transit of *Mercury* on the 11th of November. At sunrise the eastern part of the sky was almost cloudless, and continued so till the emersion of the planet. The Sun's limb, however, in consequence of his low altitude and the state of the atmosphere, was very undulating.

Mercury was seen upon the Sun's disk immediately after sunrise, his appearance as a round black spot contrasting strongly with that of some ordinary spots on the Sun's surface.

The instruments used, in different rooms, were the Northumberland Equatoreal, of 7 feet 4 inches focal length and 5 inches aperture, and the Fraunhofer Equatoreal, of 8 feet 3 inches focal length and 6.5 inches aperture.

The internal and external contacts were observed as follows, in Durham sidereal time :—

	Northumberland Telescope. Prof. Chevallier.	Fraunhofer's Telescope. Mr. A. Marth.
	^h ^m ^s	^h ^m ^s
Internal contact ...	12 38 52.68	12 38 54.0
External contact ...	12 40 53.61	12 40 59.0

Each of these observations was difficult, in consequence of the undulations of the Sun's limb. An instant before the internal contact, the thin curved line of light between the planet and the Sun's limb seemed to break up, by the sudden filling up of the two cusps by a black space. This appearance was, no doubt, occasioned by the tremulous motion affecting the Sun's limb. The exact time of the external contact was rendered uncertain from the same cause.

The times, computed from Le Verrier's Tables by the formulæ given by Dr. Schjellerupp (*Astronomische Nachrichten*, No. 1286), are,

	Durham Sid. Time.
	^h ^m ^s
Internal contact ...	12 38 55.12
External contact ...	12 41 10.60

Mr. Marth made the following observations of the difference of R.A. and declination of the Sun and planet, with a wire micrometer, each observation in R.A. being made on five wires, and five different measures having been taken of the difference of declination of *Mercury* and the Sun's northern limb :

Durham Sid. Time, Nov. 11.	Greenwich M.T.	Diff. of R.A. $\odot - \text{Mer.}$ corrected for Refraction and Proper Motion.	No. of Obs.	Corrected for Parallax.	Computed from Schjellerupp.	C—O.
^h ^m ^s	^h ^m ^s	^s		^s	^s	^s
11 58 22.9	20 38 49.5	-11.192	2	-11.308	-11.558	-0.25
12 5 8.0	45 33.4	-13.770	2	-13.883	-14.111	-0.23
28 16.7	21 8 38.4	-22.871	2	-22.971	-22.886	+ .08

	Diff. of Decl. $\odot - \text{Mer.}$ N. Limb.	No. of Meas- ures.	Corrected for Parallax.
^h ^m ^s	^s		^s
12 ^h 21 ^m 5 ^s .4	21 ^h 1 ^m 28 ^s .2	-2' 6".96	5 -2' 3".45 -1' 59".07 +4".38

*Observations of the Transit of Mercury, November 11, 1861,
at and near Liverpool.*

(Communicated by Mr. Hartnup.)

Observed by Mr. Hartnup, at the Liverpool Observatory, with the Equatoreal Refractor, aperture reduced to 4 inches, power 288, parallel wire micrometer.

By mean of 6 measures, equatoreal diameter = $10^{\circ}09'$

By mean of 6 measures, polar diameter = $9^{\circ}72'$

The tremor was great, but the observations were taken with great care.

Egress.

Interior contact..... $21^{\text{h}} 19^{\text{m}} 14^{\text{s}}.40$ G.M.T.

Exterior contact ... $21^{\text{h}} 21^{\text{m}} 25^{\text{s}}.74$

The time was taken from the sidereal clock, which was $3^{\text{h}} 33'$ fast. The fine line of light appeared broken at $12^{\text{h}} 33^{\text{m}} 9^{\text{s}}$, but it instantly united again, and between 9° and 20° it broke and united several times; after 20° the separation remained permanent. I have taken $14^{\text{s}}.5$ as the most probable time of interior contact. Contrary to expectation, the last contact was observed with less difficulty than the first; the separation of the planet from the Sun's limb was instantaneous, and may, I think, be depended on to one second of time.

Egress observed by John Joynson, Esq., at Waterloo, near Liverpool:—

Interior contact ... $21^{\text{h}} 19^{\text{m}} 14^{\text{s}}.5$ G.M.T.

Exterior contact... $21^{\text{h}} 21^{\text{m}} 9^{\text{s}}.5$

Latitude $53^{\circ} 28' 24''$ N. Longitude $3^{\circ} 1' 44''$ W.

Observed with a refractor of $3\frac{1}{2}$ inches aperture and 50 inches focal length. The time was taken from a chronometer, the error of which was obtained from the Liverpool Observatory.

Egress observed by Matthew Jee, Esq., at Edge Hill, Liverpool:—

Interior contact ... $21^{\text{h}} 20^{\text{m}} 0^{\text{s}}$ G.M.T.

Exterior contact... $21^{\text{h}} 21^{\text{m}} 20^{\text{s}}$

Latitude $53^{\circ} 24' 27''$ N. Longitude $11^{\circ} 49' 4''$ W.

Observed with a Dollond's refractor, $2\frac{1}{2}$ inches aperture ; power 80. The time was taken from the seconds clock in the office-window of the Magnetic Telegraph Company. This clock is controlled from the Liverpool Observatory.

The Transit of Mercury, November 11, 1861, observed at Grantham. By J. W. Jeans, Esq.

Lat. $52^{\circ} 54' 52''$ N. Long. $0^{\circ} 39' 0''$ W.

Morning fine, but rather hazy ; a good many light clouds ; wind moderate, and atmosphere very tremulous ; vision at times good. The first observation I consider very fair, the last rather uncertain ; telescope 5 feet focal length, achromatic, of 4 inches aperture, reduced to 2 inches ; power 80. I was rather impressed with the idea that the figure of *Mercury* was not quite round, but slightly elongated, and that there was also a slight ashy light on his eastern limb. At best visions the outline of the planet was sharp, and the impression of ellipticity doubtful ; no appearance of atmosphere ; clock corrected by transit of δ *Leonis* the same morning, and by Fomalhaut and Markab the previous evening.

First break (pretty good)...	$12^{\text{h}} 42^{\text{m}} 38^{\text{s}}.03$	} Apparent Local Sid. Time.
Last contact (middling) ...	$12 44 44.03$	

Grantham, December 5, 1851.

*Observations of the Transit of Mercury, November 11, 1861.
By Joseph Baxendell, Esq.*

The following observations were made at Mr. Worthington's Observatory, the instrument used being the equatorially-mounted achromatic of 5 inches aperture and 70 inches focal length. A power of 126 was first applied ; but, owing to the unsteadiness of the atmosphere at so low an altitude, micro-metrical measurements of the diameter of *Mercury* were found to be quite impracticable. Two measures of the planet's position on the Sun's disk were taken under a power of 68, but a light cirrous cloud was passing slowly over the Sun at the time, and the images were still very tremulous. The mean result, corrected for refraction and parallax, was as follows :—

At $214^{\text{h}} 10^{\text{m}} 2^{\text{s}}$ G.M.T. App. R.A. of *Mercury* = App. R.A. of Sun $- 20^{\circ} 74'$
 App. N.P.D. of *Mercury* = App. N.P.D. of Sun $- 14' 14''.5$

A few minutes before the end of the transit the cloud passed away, and the definition of the planet and of the Sun's limb improved considerably, and the internal and external contacts were observed very satisfactorily.

The internal contact took place at	^h 21	^m 19	^s 8.68	G.M.T.
The external	ditto	21	21	22.80 ,,

When the planet was about one-fourth or one-third of its own diameter from the Sun's limb, its form was observed to change slightly; and at the moment of internal contact it was decidedly egg-shaped, the small end of the egg being next to the Sun's limb. The only other feature observed worthy of notice was the excessive *blackness* of the planet, as compared with the nuclei of the spots then visible on the solar disk.

In connexion with the apparent alteration of form of the planet, I may perhaps be allowed to give an extract from my journal, describing a similar appearance observed by my friend Mr. S. W. Williamson, of Cheetham Hill, and myself, on the occasion of the transit of *Mercury* which occurred Nov. 9th, 1848. The telescope employed was an excellent equatorially-mounted achromatic, of $3\frac{1}{4}$ inches aperture and 42 inches focal length, belonging to Mr. Williamson, and the image of the Sun was thrown on a screen. This image was very well defined, and exhibited the usual features of the solar surface with great distinctness:—

“At the ingress of the planet a remarkable distortion of its image took place. When the planet had advanced nearly its own diameter on the Sun's disk, the image, instead of immediately assuming a full circular figure, gradually lengthened out on the following side into a pear-like form, until the planet had advanced about one-and-a-half of its own diameter on the Sun's disk, when the projecting part disappeared instantaneously, and the Sun's light closed round the planet, exhibiting it removed a very sensible distance from the limb of the Sun.”

As the apparent diameter of *Mercury*, when on the sun's disk, is probably diminished by the effect of irradiation, the alteration of its form, on approaching or leaving the limb, as noticed by some observers, may perhaps be due to the diminished effect of irradiation consequent upon the rapidly diminishing intensity of the Sun's light near the limb, and to the greater susceptibility of some eyes than others to the effects of irradiation; and I may remark that, to my own eye, the degradation of the light of the Sun's disk near the border, whether seen directly through the telescope or projected on a screen, is always very strikingly evident.

Manchester, Dec. 12, 1861.

On the Elements of the Variable Star R Sagittæ.

By Joseph Baxendell, Esq.

This star was discovered to be variable in October, 1859; and in a notice of it which I communicated to the Physical Section of the Manchester Literary and Philosophical Society, on the 5th January, 1860, its period was stated to be about 74 days, and its range of variation to be from the 9·8 magnitude at minimum to the 8·4 magnitude at maximum. The observations which I have since made have, however, enabled me to determine its elements with much greater accuracy than could be expected in a first approximation, and have also shown that it merits attention as being one of the very few but interesting variables, the light-curves whereof exhibit a distinctly marked *secondary* minimum. Many of the variables occasionally exhibit decided deviations from the ordinary course of their changes; but the cases are very rare in which a secondary minimum forms a permanent feature in the curves laid down from observations extending over several successive periods.

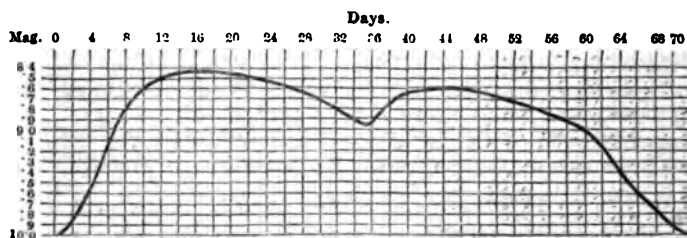
During the two years which have elapsed since I first noticed the variability of R *Sagittæ*, I have obtained the following determinations of the times of nine of its principal minima :—

- | | |
|------------------|------------------|
| 1. 1859, Oct. 27 | 6. 1860, Dec. 27 |
| 2. 1860, Jan. 7 | 7. 1861, May 17 |
| 3. „ May 31 | 8. „ July 25 |
| 4. „ Aug. 7 | 9. „ Oct. 8 |
| 5. „ Oct. 19 | |

Treating the equations formed from these data by the method of least squares, I find that the

Epoch = 1860, Oct. 17·13

Period = 70·88 days



Light-curve of R *Sagittæ*. Period = 70·88 days.

Calculating the times of the minima by means of these elements, and comparing the calculated with the observed results, we have

C - O. days.	C - O. days.
1. + 1.73	6. + 0.01
2. + 0.61	7. + 0.77
3. - 2.63	8. + 2.65
4. + 0.25	9. - 1.47
5. - 1.87	

These differences show that the variations in the length of the period of *R Sagittæ* are confined within moderate limits, and that this star may be ranked in the class of moderately regular variables.

Using the mean period of 70.88 days in combining all the observations made in the different phases of the star's changes, and projecting the mean results in the usual way, I find, from the curve thus obtained, that the principal maximum, the secondary minimum, and the secondary maximum, follow the principal minimum in 17, 35, and 44 days respectively. It appears, therefore, that the interval between the principal and the secondary minimum is almost exactly one-half of the whole period, precisely as in the case of the well-known double-period variable, β *Lyrae*.

The mean magnitude at the principal minimum = 10.00
 „ maximum = 8.45
 secondary minimum = 8.95
 „ maximum = 8.60

The lowest minimum yet observed is 10.3, and the highest maximum 8.3; the greatest range of variation is, therefore, 2.0 magnitudes.

The mean place of the star for 1860.0 is

R.A. 20^h 7^m 40^s; Decl. 16° 18' 3" N.

Manchester, Dec. 9, 1861.

On the Variable Star R Vulpeculæ. By G. Knott, Esq.

R Vulpeculæ. Piazzi xx. 457. My earliest observations of this variable were made on the 7th, 9th, and 10th of September, when it shone as a star of the 9.3 magnitude. Bad weather and absence from home prevented another observation till the 26th of the month, when, to my surprise, I found it considerably fainter, and of the 11.7 maguitude. Since that date I have

kept the star pretty constantly in view; and the discussion and projection of my observations give October 27th as the epoch of *minimum*, just two days prior to the date of probable *maximum*, as given in Mr. Pogson's ephemeris. The magnitude at minimum appears to have been about 13·6.

As this is the first communication I have had the honour of submitting to the Astronomical Society, it will probably be deemed desirable that I should briefly describe my instrument and method of observing variable stars.

My Observatory is furnished with a 9-foot equatoreal, the object-glass by Messrs. Alvan Clark and Sons, and of 7½ inches aperture. It was formerly in the possession of the Rev. W. R. Dawes, and was very favourably spoken of by him—a sufficient guarantee of its quality. I usually employ an excellent positive eyepiece, constructed for me by Mr. Dollond; it has a large field, and gives a magnifying power of 60, as determined by measuring the emergent pencil. Higher magnifiers are occasionally employed.

In observing and discussing observations of variable stars, I have adopted Mr. Pogson's methods, as also his magnitude-scale (Argelander's extended). I am largely indebted to him, not only for his interesting and important papers in the *Astronomische Nachrichten* and the *Monthly Notices*, but also for several valuable hints in one or two personal communications with which he has favoured me. In all probability I am not the only amateur who is eagerly expecting his promised *Variable Star Atlas*.

Observations of Comet II. 1861, taken with the Equatoreal of the Liverpool Observatory. By J. Hartnup, Esq.

	G.M.T.				Comet's R.A.			Log. $\frac{P}{L}$	Comet's N.P.D.			Log. $\frac{Q}{P}$	Stars of Comp. B.A.C.
1861.	h	m	s		h	m	s		°	'	"		
July 3	10	44	32·7		9	42	13·06	+8·950	24	5	59·1	-9·7407	3496
3	11	21	16·0		9	44	3·75	+8·910	24	2	49·5	-9·7955	"
4	10	54	4·6		10	50	43·43	+8·999	23	5	31·0	-9·6858	3647
4	11	25	20·0		10	52	4·32	+8·985	23	5	33·0	-9·7790	"
4	11	56	34·8		10	53	25·01	+8·962	23	5	38·1	-9·8644	"
5	11	3	34·1		11	46	10·28	+8·996	23	40	24·6	-9·5207	3968
5	11	29	11·1		11	46	50·71	+8·993	23	41	20·6	-9·5831	"
5	11	49	48·5		11	47	31·40	+8·987	23	42	20·9	-9·6337	"
6	10	3	56·4		12	25	23·85	+8·938	24	54	1·5	-9·0806	4276
6	10	24	23·6		12	25	53·65	+8·953	24	55	15·0	-9·2173	"
6	10	44	50·5		12	26	23·61	+8·963	24	56	30·5	-9·3213	"
7	10	24	25·2		12	55	52·79	+8·909	26	26	4·5	-9·1219	4300
7	10	54	53·7		12	56	24·84	+8·931	26	28	3·7	-9·2909	4276

	G.M.T.			Comet's R.A.			Log. $\frac{p}{P}$	Comet's N.P.D.			Log. $\frac{q}{Q}$	Stars of Comp. B.A.C.
1861.	h	m	s	h	m	s		°	'	"		
July 7	11	25	21.4	12	56	57.20	+8.944	26	30	6.0	-9.4211	4276
8	10	58	56.3	13	18	27.06	+8.899	27	58	53.4	-9.2692	4392
8	11	24	13.0	13	18	46.90	+8.914	28	0	29.3	-9.3821	"
Sept. 1	10	12	11.3	15	34	31.60	+8.729	46	30	14.5	-9.6909	5287
1	10	37	8.7	15	34	32.56	+8.737	46	30	21.4	-9.7283	"
3	8	52	44.6	15	36	47.77	+8.671	46	40	48.6	-9.5688	"
3	9	12	43.0	15	36	48.59	+8.692	46	40	50.8	-9.6042	"

The observations are corrected for refraction. The corrections to be applied for parallax in time and arc are represented by p and q ; P is the equatoreal horizontal parallax. The following are the assumed mean places of the stars of comparison for 1861, Jan. 0.

	R.A.			N.P.D.			Authority.
B.A.C.	h	m	s	°	'	"	
3496	10	7	53.88	24	12	1.54	Greenwich and Oxford Obs.
" 3647	10	32	25.51	23	33	25.95	" " "
" 3968	11	34	41.03	22	29	9.61	British Association Catalogue.
" 4276	12	35	28.67	26	31	24.03	" " "
" 4300	12	41	21.66	26	27	33.40	" " "
" 4392	13	0	53.52	27	12	43.14	" " "
" 5287	15	50	0.14	46	27	17.79	" " "

Variations in the Light of η Argus, observed at Madras from 1853 to 1861. By Eyre B. Powell, Esq.

Mr. Powell writes that he has been engaged, off and on, during the last four years in watching the nebula about η Argus, and in taking micrometrical observations of the neighbouring stars; consequently his attention has been very much directed to that part of the heavens, and the estimations of the magnitude of that star have been made with very great care. The observations are as follows:—

- 1853.991. η Argus slightly inferior to α Centauri, but superior to either α Crucis or β Centauri.
- 1854.076. Inferior to α but superior to β Centauri. Rays issue from η as from Rigel.
- 1855.967. Not brighter than Procyon, and not quite so bright as Capella; scarcely brighter than α Crucis, about equal to β Centauri. Colour reddish or yellowish white; star scintillates.
- 1856.012. Scarcely brighter than β Centauri, a trifle brighter than α Crucis; scintillates more than either, and is reddish. Perhaps equals β Centauri, but, being reddish, strikes the eye more.

- 1858:36-. Less than γ *Crucis*, but very little different.
- { 1858:44. Certainly inferior to β *Crucis*, and, I think, to γ *Crucis*.
- { 1858:49. Less than γ *Crucis*.
- { 1858:48. Decidedly less than γ *Crucis*, but is considerably lower. A little brighter than ϵ *Sagittarii*, both stars having about the same altitude.
- { 1859:274. Considerably less than γ *Crucis*.
- { 1859:328. Much less than γ *Crucis*; a little less than δ *Argus*; a little greater than δ *Crucis*.
- { 1859:931. About equal to δ *Centauri*; a little greater than ϵ *Argus*.
- { 1859:98. Equal to δ *Centauri*; a little greater than ϵ *Argus*; certainly less than γ *Centauri*.
- { 1860:165. Decidedly less than δ *Centauri*; about equal to δ *Crucis*.
- { 1860:181. Equal to δ *Crucis* nearly, perhaps a trifle superior; both stars require attention to catch them in full moonlight.
- { 1860:287. Equal to δ *Crucis*; not much greater than ϵ *Argus*.
- { 1860:326. Equal to δ *Crucis*, the stars having about equal altitudes.
- { 1860:972. A little less than δ *Crucis*.
- { 1861:014. Less than δ *Crucis*; less than ϵ *Argus*.
- { 1861:249. Less than δ *Crucis*; less than ϵ *Argus*.
- { 1861:282. With telescope, less than the principal star in ϵ *Argus*.

Taking the observations in groups according to the brackets, and using Sir John Herschel's photometric magnitudes for the reference-stars, the following approximate table is obtained. Where a star of reference does not occur in Sir John Herschel's list (as is the case with δ *Crucis*, for example), γ has been added to the ordinary magnitude, to bring it to the photometric scale.

Epoch.	Photometric Mag.
1854:03	1.2
1855:99	1.5
1858:44	2.3
1859:3	3.1
1859:95	3.3
1860:24	3.4
1861:13	3.6

The break in the observations between 1856 and 1858 arises from my having been absent from India during that interval.

Madras, November 4th, 1861.

Results of Meridional Observations of Small Planets; Occultation of Stars by the Moon; and Phenomena of Jupiter's Satellites; observed at the Royal Observatory, Greenwich, during the month of November, 1861.

(Communicated by the Astronomer Royal.)

Victoria (19).

Mean Solar Time of Observation.			R. A. from Observation.	N.P.D. from Observation.
		^h ^m ^s	^h ^m ^s	[°] ['] ["]
1861, Nov.	2	12 26 22.8	3 15 23.10	69 42 26.18
	7	12 1 26.9	3 10 5.87	70 22 59.01
	8	11 56 27.2	3 9 1.94	70 31 13.92
	11	11 41 30.4	3 5 52.33	70 56 8.14
	19	11 2 1.3	2 57 49.22	72 2 22.22
	20	10 57 9.1	2 56 52.76	72 10 22.27
	30	10 9 31.5	2 48 32.93	73 26 7.39

Irene (14).

Mean Solar Time of Observation.			R. A. from Observation.	N.P.D. from Observation.
		^h ^m ^s	^h ^m ^s	[°] ['] ["]
1861, Nov.	2	11 36 7.1	2 24 59.11	86 47 6.18
	5	11 21 31.6	2 22 10.86	86 54 23.36
	11	10 52 30.1	2 16 43.98	87 5 52.52
	20	10 9 42.2	2 9 18.07	87 13 59.66
	27	9 37 19.5	2 4 25.97	87 12 8.12
	30	9 23 44.6	2 2 38.52	87 9 1.75

Ariadne (43).

Mean Solar Time of Observation.			R. A. from Observation.	N.P.D. from Observation.
		^h ^m ^s	^h ^m ^s	[°] ['] ["]
1861, Nov.	5	9 30 0.4	0 30 21.41	81 17 5.99
	7	9 21 22.0	0 29 34.71	81 27 33.29
	11	9 4 28.2	0 28 24.37	81 46 22.36
	19	8 32 8.9	0 27 32.20	82 14 58.30
	20	8 28 15.1	0 27 34.28	82 17 27.00
	27	8 1 43.9	0 28 34.64	82 30 34.84

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Europa (20).

Mean Solar Time of Observation.			R.A. from Observation.	N.P.D. from Observation.
	^h ^m ^s		^h ^m ^s	[°] ['] ^{''}
1861, Nov. 5	9 40 50.9		0 41 13.68	95 58 39.84
7	9 32 3.7		0 40 18.14	96 0 29.62
11	9 14 53.1		0 38 50.96	96 3 46.32
20	8 37 17.0		0 36 37.71	95 59 27.43
30	7 57 30.1		0 36 9.84	95 39 58.27

All the observations of N.P.D. have been corrected for refraction and parallax.

Occultations of Stars by the Moon.

Day of Obs.	Phenomenon.	Moon's Limb.	Mean Solar Time.	Observer.
			^h ^m ^s	
1861, Nov. 6	B.A.C. 6448 disapp. (a)	Dark	6 35 26.4	D.
17	33 Tauri, disapp. (b)	Bright	10 12 45.7	J. C.
17	33 Tauri, reapp. (b)	Dark	11 6 51.8	J. C.

(a) Clouds passing over the moon. (b) Somewhat unsatisfactory.
The initials D. and J. C., are those of Mr. Dunkin and Mr. Carpenter.

Phenomena of Jupiter's Satellites.

Day of Ob- servation.	Satellite.	Phenomenon.	Mean Solar Time.	Observer.
^{1861.}			^h ^m ^s	
Nov. 18	IV	Occ. reapp. first cont. (a)	16 32 4.8	J. C.
18	IV	„ bisection (a)	16 45 34.2	J. C.
18	IV	„ last cont. (a)	16 48 33.7	J. C.
27	I	Ecl. disapp. (b)	14 21 49.4	D.

(a) The planet's image extremely bad. (b) The sky very hazy.
The initials as before.

*Observations of Comet II., 1861, made with the Heliometer
at the Radcliffe Observatory, Oxford. By the Rev.
R. Main.*

Day.	Greenwich M.T.	Apparent R.A.	Apparent N.P.D.
^{1861.}	^h ^m ^s	^h ^m ^s	[°] ['] ^{''}
June 30	11 1 47.4	6 40 13.07	43 25 11.1
	11 29 36.1	6 41 6.02	43 14 34.5
July 2	11 23 2.8	8 32 23.31	27 31 1.1
	11 30 4.3	8 32 45.14	27 29 42.9

Day. 1861.	Greenwich M.T. h m s	Apparent R.A. h m s	Apparent N.P.D. ° ' "
July 3	9 31 58.2	9 38 37.98	24 12 49.7
	9 47 43.2	9 39 24.94	24 11 24.8
4	11 5 17.8	10 51 13.03	23 5 24.7
	11 12 31.1	10 51 31.08	23 5 24.4
5	9 17 25.0	11 42 29.24	23 36 1.9
	9 22 47.1	11 42 39.82	23 36 3.6
	9 26 17.5	11 42 49.05	23 36 21.4
	9 33 42.3	11 43 1.49	
6	9 47 58.0	12 25 1.27	24 53 0.9
	9 52 59.2	12 25 8.45	24 53 24.7
	9 57 8.9	12 25 15.06	24 53 38.7
8	10 27 22.0	13 18 1.07	27 56 35.3
	10 32 14.9	13 18 5.28	27 56 53.7
	10 38 51.7	13 18 10.79	27 57 25.3
	10 43 25.5	13 18 14.18	27 57 37.7
9	9 24 58.9	13 34 7.30	29 18 1.1
	9 33 26.5	13 34 12.91	29 18 39.3
	9 39 15.2	13 34 15.56	29 18 51.2
	10 5 31.0	13 34 30.55	29 20 20.9
10	10 22 28.1	13 47 35.60	30 38 46.1
	10 28 9.6	13 47 38.39	30 39 8.7
	10 33 14.2	13 47 40.79	30 39 25.5
	10 37 7.9	13 47 42.46	30 39 37.2
14	10 43 14.6	14 18 43.61	34 36 9.1
	10 48 39.7	14 18 45.39	34 36 24.7
	10 57 46.4	14 18 46.56	34 36 40.8
	11 6 3.9	14 18 49.10	34 36 58.6
	11 15 44.2	14 18 51.30	34 37 19.9
15	9 44 22.2	14 23 27.83	35 19 24.8
	9 54 15.1	14 23 29.59	35 19 31.6
	10 5 25.7	14 23 31.19	35 19 54.3
16	10 40 16.0	14 27 48.53	36 1 55.8
	10 45 23.2	14 27 49.36	36 2 7.8
	10 51 18.4	14 27 48.82	
	10 57 2.5	14 27 50.92	36 2 20.0
	11 2 53.3	14 27 51.96	
	11 8 22.6	14 27 52.87	
	11 15 53.2		36 2 44.1
	11 21 22.3		36 2 59.5
23	10 43 26.3	14 46 (15.16)	39 27 1.4
	11 16 56.2	14 46 43.04	39 27 19.7
	11 37 21.4	14 46 44.82	39 27 19.1
	12 7 47.9	14 46 46.98	39 27 34.1

July 23. Something wrong in the first observation of R.A.

Day. 1861.	Greenwich M.T. h m s	Apparent R.A. h m s	Apparent N.P.D. ° ' "
July 26	10 13 5'7	14 51 50'00	40 26 14'0
Aug. 1	10 3 43'2	15 0 7'24	42 1 52'4
	10 27 56'9	15 0 7'79	42 1 55'1
	10 44 43'1	15 0 9'40	42 1 55'8
	11 11 31'6	15 0 10'00	42 2 5'3
2	9 40 17'7	15 1 27'09	42 14 43'3
	10 13 40'3	15 1 25'41	42 14 47'8
6	11 3 26'2	15 6 0'50	43 4 3'9
	11 21 32'1	15 6 0'59	43 4 21'1
	11 38 2'0	15 6 1'70	43 4 38'0
	11 53 53'0	15 6 2'55	43 5 2'9
8	11 9 44'2	15 8 14'14	43 26 16'3
	11 31 37'9	15 8 15'83	43 26 13'0
	11 47 20'9	15 8 16'60	43 26 25'4
15	10 55 9'2	15 15 45'79	44 32 44'2
	11 8 42'2	15 15 45'04	43 32 50'0
	11 22 16'8	15 15 47'56	44 32 28'4
16	8 41 9'1	15 16 45'72	44 40 1'4
	8 54 2'8	15 16 46'22	44 40 16'8
	10 6 21'4	15 16 49'40	44 40 29'2
	10 32 28'7	15 16 49'52	44 40 44'6
	10 49 21'9	15 16 50'29	44 40 29'2
19	8 43 2'5	15 19 58'65	45 3 59'6
	9 30 1'7	15 20 0'79	45 4 26'8
	9 43 22'6	15 20 0'96	45 4 29'5
	9 58 29'4	15 20 1'19	45 4 34'8
20	8 35 53'7	15 21 2'46	45 11 45'2
	8 57 18'5	15 21 3'49	45 11 58'8
	9 13 57'0	15 21 3'73	45 11 55'6
	9 48 24'4	15 21 5'75	45 12 6'1
	10 5 56'5	15 21 6'87	45 12 18'4
23	8 48 29'1	15 24 18'35	45 33 24'8
	9 23 49'1	15 24 20'49	45 33 36'9
	9 49 13'5	15 24 20'89	45 33 42'1
	10 1 45'2	15 24 21'31	45 33 44'7
	10 29 47'4	15 24 23'90	45 34 0'0
26	9 28 16'1	15 27 40'96	45 53 47'4
	9 52 15'2	15 27 41'82	45 53 47'7
	10 7 18'8	15 27 42'73	45 54 3'2
	10 16 30'0	15 27 43'56	45 54 10'0
27	8 16 20'7	15 28 43'86	45 59 48'6
	8 41 11'6	15 28 44'71	45 59 53'9
	8 55 45'7	15 28 45'73	45 59 55'9
	9 43 22'5	15 28 48'51	46 0 8'1

Day. 1861.	Greenwich M.T. h m s	Apparent R.A. h m s	Apparent N.P.D. ° ' "
Aug. 27	10 25 55.5	15 28 49.45	46 0 25.7
30	9 15 48.9	15 32 10.80	46 18 22.6
	9 50 49.0	15 32 10.25	46 17 56.3
	10 36 9.5	15 32 15.05	46 17 37.0
Sept. 3	8 15 56.4	15 36 45.81	46 40 20.8
	8 31 56.7	15 36 46.66	46 40 33.7
	9 16 45.7	15 36 49.56	46 40 42.1
	9 36 50.4	15 36 47.67	46 40 44.5
	10 1 3.9	15 36 51.25	46 40 55.3
6	8 32 12.2	15 40 20.60	46 55 41.6
	8 54 41.5	15 40 20.76	46 56 0.9
	9 5 53.6	15 40 22.74	46 55 53.8
	10 2 13.2	15 40 25.27	46 56 11.2
10	8 50 0.4	15 45 13.54	47 14 15.9
	9 10 8.7	15 45 13.66	47 14 28.0
	9 23 45.9	15 45 14.78	47 14 15.2
	9 42 52.8	15 45 15.70	47 14 26.0
12	8 32 28.1	15 47 39.65	47 22 52.6
	9 0 54.2	15 47 42.12	47 22 49.1
	9 20 50.2	15 47 43.15	47 22 49.7
	9 38 57.9	15 47 43.78	47 22 55.3
14	7 53 48.9	15 50 9.91	47 30 31.6
	8 12 44.6	15 50 9.01	47 30 18.5
	8 34 43.2	15 50 12.10	47 30 28.7
	9 13 14.7	15 50 14.21	47 30 42.5
	9 26 59.5	15 50 15.75	47 30 45.9
17	9 14 5.8	15 54 2.74	47 41 37.5

Of the preceding observations, those to July 16 inclusive were made by myself, and the remainder were made by Mr. Quirling. A wire micrometer, furnished with a single fixed transit-wire and with a declination wire moveable by the screw, was used till the faintness of the comet made it necessary to observe in a dark field over thicker wires, when a negative eye-piece with metallic cross was substituted. This change occurred on Aug. 16. But, in all cases, the declination wire was used in a fixed position, and the reading of one microscope of the hour-circle and of one microscope of the declination-circle was taken for each observation of the comet and the stars of comparison. These stars were generally taken from the Radcliffe Catalogue, and were in general so near to the comet on the night of observation that the differential effect of instrumental errors will be insignificant. On July 15 and 16 the transits of the star and comet were made with an unchanged position of the polar axis, though the circles were read as on other evenings, and the results for these evenings are

obtained by application of the index corrections obtained on other evenings.

All the observations are corrected for the effects of refraction and parallax.

The following is a list of the stars of comparison, together with the places assumed in the reduction of the observations.

Mean Places for 1861, Jan. 1, of Stars compared with the Great Comet of 1861.

Day of Comp. 1861.	Name.	Mean R.A. h m s	Mean N.P.D. ° ' "	Authority.
June 30	Capella	5 6 25.55	44 8 53.1	Nautical Almanac.
July 2	α Urs. Maj.	8 18 41.06	28 49 17.5	Radcliffe Catalogue.
3	β Urs. Maj.	9 20 31.72	26 20 0.7	" "
4	α Urs. Maj.	10 55 7.25	27 29 58.7	Nautical Almanac.
5	" "	" "	" "	" "
"	γ Urs. Maj.	11 46 30.19	35 31 57.0	" "
6	76 Urs. Maj.	12 35 28.81	26 31 24.6	Radcliffe Catalogue.
8	83 Urs. Maj.	13 35 27.54	34 36 50.3	" "
9	81 Urs. Maj.	13 28 46.58	33 56 17.7	" "
10	84 Urs. Maj.	13 41 24.15	34 52 19.1	" "
14	*	14 23 49.0	34 38 0.0	
15	*	" "	" "	
16	*	14 27 40.0	36 2 0.0	
"	B.A.C. 4826	14 28 57.27	36 29 21.0	Radcliffe Catalogue.
23	B.A.C. 4937	14 51 46.18	39 48 7.4	" "
26	" "	" "	" "	" "
Aug. 1	44 Boötis (2 ^d)	14 59 12.46	41 48 11.3	" "
2	" "	" "	" "	" "
6	" "	" "	" "	" "
8	Rümker 5030	15 13 32.37	43 52 19.7	Rümker's Cat.
15	Oeltz. Arg. 15347	15 19 24.07	44 14 8.1	Oeltzen-Argel. Cat.
16	Rümker 5050	15 15 53.52	45 3 32.0	Rümker's Cat.
19	Radcliffe 3387	15 21 13.65	45 12 35.4	Radcliffe Catalogue
20	" "	" "	" "	" "
23	Radcliffe 3387	15 21 38.49	45 30 23.4	" "
26	B.A.C. 5175	15 33 40.19	45 56 28.0	" "
27	" "	" "	" "	" "
29	" "	" "	" "	" "
30	" "	" "	" "	" "
Sept. 3	" "	" "	" "	" "
6	Radcliffe 3448	15 41 28.95	47 5 56.0	" "
10	↓ Hercules	15 47 52.16	47 9 27.7	" "
12	" "	" "	" "	" "
14	4 Hercules	15 50 50.05	47 1 39.65	" "
17	" "	" "	" "	" "

On June 30 the comet was also observed on the meridian with the transit-instrument and the meridian-circle, and the following is the result of the observation :—

1861, June 30	12 ^h 11 ^m 5 ^s .9	Greenwich Mean Solar Time.
	Apparent R.A.	6 ^h 42 ^m 10 ^s .89
	Apparent N.P.D.	42° 56' 56".1

the N.P.D. being corrected for refraction and parallax.

The following are the notes which I made on the appearance of the comet :—

1861, June 30. This splendid comet burst suddenly on the view this evening. I saw it first at about 10 o'clock, and immediately prepared to observe it. Its appearance, notwithstanding the strong daylight, was most brilliant. To the naked eye the condensation of light about the head was so great as to bear comparison with the Moon rather than with any other object. In fact the diameter of the coma was about 30' by measurement at some Observatories on this evening. The tail streamed vertically upwards, and near midnight could be traced considerably beyond *Polaris*, which it passed over. Its length on this evening has been variously estimated from 100° to 120° by the most careful observers.

In the telescope of the heliometer there appeared a nucleus of an elliptical shape, with its major axis a little inclined to the vertical, that is, directed nearly towards the Sun. It was about the size of the ball of *Saturn*, near opposition, or about 20" in diameter. A stream of light went off from the upper apparent part of the nucleus, and turned round towards the apparent west in the shape of a sickle. Another but fainter stream was seen on the apparent east side of the first stream, also turning round towards the west.

July 2. In appearance not very different from that on June 30. A sickle-shaped stream of light setting out westward (apparently), and seeming for a little distance parallel to the declination wire, and then turning rapidly downwards (that is, away from the Sun). The nucleus elliptical as before, with its major axis inclined at an angle of 15° to the declination wire. The second stream of light was visible, but not so well defined as before. Clouds rendered physical observations difficult. The tail at least 70° in length.

July 3. The evening was too cloudy for accurate physical observations, but it appeared as if the formations round the nucleus were becoming more regular and concentric, and more like Donati's comet. At midnight the clouds cleared away, and the view of the comet with the naked eye was magnificent. The tail was about 60° in length, being visible beyond the zenith.

July 4. The comet is rapidly becoming fainter. The tail could not be traced farther than 40° from the nucleus, but the brilliancy of the nucleus is still very great. In the telescope the nucleus appeared pear-shaped, with the point (apparently westward) and the axis parallel to the declination axis. Two curved streams of light are still seen flowing from it, the lower one sickle-shaped, but not so well defined as previously, cutting the declination wire at an angle of about 60° ; the upper arc ill defined and cutting the declination wire at an angle of 30° . The whole formed the sector of a circle of about 100° .

July 5. I examined the head of the comet to-night with a lower power. The nucleus is now very bright, and almost equal to a star of the first magnitude (I compared with α *Ursæ Majoris* in the twilight). It is of the same shape as on the preceding night. The head of the comet is altogether like a fan expanded to about 120° . Round the nucleus is a very bright circle of light, scarcely separable from it, and the two diverging streams of light now pass symmetrically on each side of the nucleus.

July 9. The shape of the head is that of an expanded fan. The nucleus terminates in a bright stellar point towards the apparent east, and is very narrow and pear-shaped, running parallel to the declination wire (or to the equator). Round the nucleus is a bright envelope of a circular shape, and, beyond that, another very faint and diffused. The distinctness of the envelope is not at all comparable with Donati's comet of 1858. The whole of the field is very strongly illuminated with the light of the comet.

July 10. The appearance of the comet has not materially changed since last night, except that the shape of the nucleus is materially different, having become more obtuse.

By my directions, Mr. Quirling confined himself for several evenings after the first appearance of the comet to observations of the length, breadth, and peculiarities of the tail, and incorporated the results of his observations in a series of drawings, in which the position and magnitude of the tail are defined accurately by means of the stars which it passed over or near to. The following is an abstract of his observations:—

"July 4. This was the first favourable evening after June 30 for observations of the tail. At $10^h 40^m$ the head of the comet was nearly in a line with α and β *Ursæ Majoris*, and the northern boundary of the tail passed just over α *Draconis*, and could be traced a short distance beyond that star. The estimated length was about 25° . The shape near the head was that of a very flat parabola, and the northern boundary was by far the brighter one.

"At $11^h 30^m$, the darkness being greater, the comet had increased considerably in apparent brightness. The northern border of the tail passed beyond α and γ *Draconis*, which were seen through it; it passed exactly over γ *Draconis*, and could

be traced towards τ *Herculis*. The southern border was far less distinct; it passed north of δ *Draconis*, of several stars of the 6th magnitude. Estimated length, about 44° .

"At 12^h , the northern border could be traced beyond μ *Herculis*; the southern border still less distinct than the northern. In the vicinity of δ *Draconis* there seemed to be faint traces of a second tail. Whole length of tail, 60° to 65° ; breadth, 7° to 8° .

"July 5, $11^h 30^m$. Sky very fine. The tail could be traced nearly to τ *Herculis*, the northern boundary being still the better defined. The southern border scarcely reached δ *Draconis*, and passed over ι and κ *Böotis*, where there was again the faint beginning of a second tail, bending northwards, as on the night before. The tail did not reach τ *Herculis*. Length, about 45° ; greatest breadth, 10° .

"July 8, $11^h 30^m$. The evening in general not favourable. The comet considerably fainter than on July 5, but still a conspicuous object in the heavens. The centre of the tail pointed midway between ϵ and χ *Herculis*; but it could not be traced up to those stars. The fan or second tail, which was observed on July 4 and 5, had entirely disappeared. Length, about 27° .

"July 9. General appearance nearly the same as on the preceding night. Length, about 20° to 24° .

"July 14. The comet considerably smaller. The head, which had been up to this time always estimated as of the 1st and 2d magnitude, was to-night decidedly not brighter than a star of the 3d magnitude. Both borders of the tail well defined, though the northern could be traced farther than the southern. Length of tail, 15° or 16° .

"July 16. The appearance very similar to that on July 14. Length, 12° or 13° ."

Progress of the Charts in course of execution at Bonn.

Communicated by Mr. Carrington, as received from Dr. Krüger, by the direction of Dr. Argelander.

Seven sections, each comprising four sheets, are published. The first four sections were received several months since by the Observatories and Astronomers to whom they are presented. Sections 5, 6, and 7 were despatched, through Marcus of Bonn, at the end of last October; and vols. iii. and iv. of the *Bonn Observations*, being vols. i. and ii. of the present *Survey*, are about to follow. The charts comprising the Zone 2° S. to 20° N., and the next, 20° N. to 40° N., are fully published; and section 7, containing sheets 26, 27, 32, 33, will amount to half the next Zone, 40° to 60° N.

The observations by zones of 2 and 3 degrees broad with the 34-lines telescope were brought to a close at 81° N. on March 27, 1859, and amount to 1841 zones. By means of auxiliary tables, the positions of all the stars of Bessel's zones, from $+15^{\circ}$ to $+45^{\circ}$ from Weisse's catalogue, Oeltzen's catalogue, &c. were brought up to 1855.0, and entered in the same ledgers (about 190 in number), which record the original entries of times of transit in the Bonn zones. In order to see by inspection that each star was twice observed, a special catalogue was transcribed, in which the positions were arranged in zones of one hour each, and one degree broad. When the two observations of each star had been thus compared, the next step was the reduction to 1855 of all the stars contained in the former Catalogues of Lalande, Bessel, Argelander, Piazz, Groombridge, Johnson, Rümker, Fedorenko, Schwerd, Struve (*Pos. Med.*), &c.; and the entering of the results alongside of those of the *Bonn Survey*; when, if the different authorities exhibited marked discrepancies, a further research was instituted. All cases of discrepancy were put aside, and entered in books for further examination or reobservation where the source of error was not easily detected.

The re-examination of the still dubious cases has been, for the most part, the special labour of Dr. Argelander himself, and a very laborious and important part of the undertaking, the necessary observations on the meridian having engaged his whole time from 1854 to 1860.

It has further been found necessary to repeat the survey in portions of the heavens unusually rich in stars, or where the previous ordinary survey had been taken during moonshine. For this purpose 476 additional Revision-Zones have been observed with a 5-foot telescope, by taking 1° only at a time in breadth, and on an average a much less extent in right ascension than those of the first survey.

In addition to the revision of doubtful stars, Professor Argelander has completely observed all stars to the 8th magnitude the positions whereof were found to be previously undetermined. The results of these observations will be embodied in a separate catalogue of about 30,000 stars observed with the meridian circle. The revision-observations of this class have been long in progress, so that the number of still undetermined stars is reduced to about 1000, and the whole is likely to be finished next summer. The reduction of these observations is somewhat in arrear, and a year or more may be required before the catalogue can be formed.

Dr. Krüger proceeds to remark, that after the correction of all known errors, the next step was the preparation of the principal catalogue, the arrangement of which he describes, but which can be seen by inspection of the work itself. He points out that the fourth volume contains a catalogue of all the errors detected at Bonn in the zones of Bessel, from -2°

to $+45^{\circ}$ decl., and states that the result of the revision appears to be, that, excepting two cases of observations of planets, the whole of the observations of Bessel agree with positions of stars which still exist. He remarks that the result affords a weighty argument against those who hastily speak of vanished stars, and that the stability of the heavens has received so strong a support that suppositions of sudden change will in future be received with the greatest mistrust.

The preparation of the principal catalogue was assigned to Prof. Schonfeld, who has continued to forward the work since his removal to Mannheim; so that now the manuscript is complete.

The preceding account relates to north declination to 81° . It was considered impossible to continue the observations in zones beyond this point, on account of the extremely slow movement of the stars, and recourse was had to the first issue of Mr. Carrington's Charts (those printed by the anastatic process), which were compared anew with the heavens by means of a large comet-seeker, the magnitudes noted, and wanting stars supplied—the last by use of the heliometer.

To complete this work there now remains only the plotting out of certain charts, and the printing by lithography; and only three sheets besides the polar chart are incomplete. The rest are partly finished, partly in the press, and partly in MSS.

The catalogue progresses simultaneously, and the third section is in the press. When this is done, there will follow the special catalogue of 30,000 stars observed on the meridian, and the correction of errors in the *Histoire Celeste*, Argelander's Northern Zones, and other catalogues.

The Fellows of the Society, and all to whom this account comes, cannot fail to admire the stately progress of this enormous work, which, simple in its conception, and free from insurmountable difficulties in execution, would appal many an astronomer by its vast extent.

The President communicated a letter from Mr. Basil Henry Cooper, "On the Egyptian Phoenix Period of 540 years, spoken of in a passage of Pliny." The letter partly relates to an eclipse of the Moon, recorded in a hieroglyphical inscription at Karnak, which the author concludes to have been that of the night of the 16 March, B.C. 851.

The President communicated observations by Mr. S. HORTON of Encke's Comet, and of the planet *Saturn*, extracted from the Hartwell Observatory Register. The comet was seen:—

	1861, Nov. 24.	Nov. 26.	Nov. 30.
Right Ascension	22 ^h 31 ^m	22 ^h 29 ^m	22 ^h 25 ^m
Declination	7° 53'	7° 29'	6° 49'
Hour Angle	2 ^h 13 ^m	4 ^h	2 ^h
Clock	0 ^h 45 ^m	2 ^h 31 ^m	0 ^h 26 ^m

Power 22 and 50.

Among the presents to the Society was included a volume of 111 Indian-ink drawings, by Mr. S. Gorton, of the planet *Jupiter*, radius about one inch, from observations made at Downs Road, Clapton, in the years 1859-60-61. The author remarks that as the observations were taken for the purpose of recording any great or marked changes in the principal belts, with an instrument of moderate size, the representation of those minute details for which great power was necessary was not attempted. The earlier drawings were made under some disadvantages—the telescope being used at a window, and not having an equatoreal mounting; this was added in April 1860, after which the planet was observed more regularly.

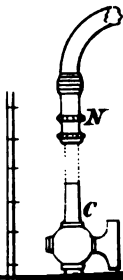
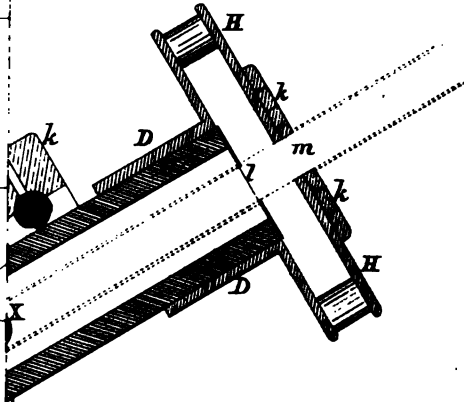
The power used was almost invariably 100; the telescope by Ross, 4 feet focal length, 3 $\frac{1}{2}$ inches aperture.

An Account of Observations on Solar Radiation.

By John James Waterston, Esq.

§ 1. In March of last year I submitted to the Society some computations with reference to the Sun's heat, and suggesting a mode of deducing the potential temperature of its radiating surface. This last summer I have endeavoured to put this method to the proof by a series of observations on solar radiation, supplemented with experiments on the rate of cooling of thermometers in air and in vacuo with different kinds of radiating surfaces; also by another series applying the method of deducing the potential temperature of a radiating surface to predicate the temperature of one that is maintained at a constant *known* temperature.

The success of these last mentioned, so far as they have as yet been carried, encourages me to lay before the Society the observations on solar radiation, with an account of the method





employed to obtain the results, and of the mode of reducing them to a vacuum.

§ 2. It will be remarked, on inspecting the chart in which the observations are projected, that a simple law of atmospheric absorption is indicated, which, if confirmed by other similar observations in different climates, would perhaps lead to more exact ideas of the influence of the atmosphere on the Sun's rays. Unfortunately the best part of the summer had passed before I could begin to observe, and there was almost constant interruption with clouds and unsettled weather. In a tropical station, where the Sun rules in a cloudless sky, the presumed law might soon be put to the test, and the heating power of the Sun's rays before entering the atmosphere ascertained with precision. Having determined this for the Earth's mean distance from the Sun, its value for any other planetary distance may be deduced by the law of the inverse square.

§ 3. When a thermometer is exposed to the Sun with its bulb blackened, it is presumed to absorb all the heat that impinges on a plane surface equal to the transverse section of the bulb; it rises and is maintained at a certain temperature; and when this balanced condition is attained we can with certainty assert that the amount that issues from the bulb is precisely equal to the quantity that enters. The elevation of its temperature above surrounding bodies due to the Sun's radiant power (which is denoted by the symbol r) would be an exact measure of that power, if no heat issued from it except by radiation, and if the rate at which heat was emitted from it increased exactly in proportion to r . Now I find that if the bulb of a thermometer is enclosed in a vacuum, the walls of which are brass, coated with lamp-black, the rate at which it cools is *exactly* proportional to the value of r , and this rate has exactly the same value, whether the glass bulb is uncoated or coated with lamp-black. When enclosed in air the rate of cooling increases faster than r . The mode of measuring the rate in both cases, and of reducing the values of r observed in air to what they would be in a vacuum, are described at the end of this paper.

§ 4. The instrument employed was designed so that the thermometer exposed to the Sun's rays should radiate against an enclosing metallic surface coated with lamp-black, and so that the temperature of that surface should always be known.

Fig. 1, with the description that accompanies it, gives the details. The rays of the Sun were admitted to strike upon the bulb of the thermometer, x , through a hole but little larger than its diameter, and were entirely screened off the brass tube against the blackened inner surface of which the radiation of the bulb took place. The thickness of the sides of the brass tube was $\frac{1}{2}$ inch, and the thermometer, y , that indicated its temperature, was lodged in a hole cut in the upper side. The circumference of the bulb touched the brass, and its upper side

was enclosed with cork, while the lower was exposed to the air within the tube, but was untouched by the rays of the Sun that passed through. The internal diameter of the tube was 0.9 inch and length 6 inches. The bulb of the solar thermometer was 0.42 inch in diameter, spherical in shape, and fixed in the centre, as shown in the figure. Its shadow was an easy guide in moving the tube in altitude and azimuth to keep pace with the Sun. It is difficult, if not impossible, to demonstrate that the thermometer, τ , shows the exact temperature of the inner surface of the tube. It was subjected to three tests.

1. The instrument being out of the Sun's rays, and x and τ showing the same temperature, it was removed to a place where the atmospheric temperature was 10° lower. Both thermometers descended and showed a difference equal to about one-tenth the amount they had to fall to arrive at the atmospheric temperature, τ being so much in advance of x .

2. A bat's-wing flame of gas was brought within 3 inches fronting the middle of the tube; both x and τ rose together, keeping pace exactly.

3. While taking observations, the heat absorbed by x from the Sun, and again emitted from it and transferred to the tube, gradually raised its temperature until a maximum was obtained. Now, comparing x and τ while both are rising, and after having obtained their maximum, a difference of $0^{\circ}.3$ was remarked, and this difference, no doubt, affected isolated observations when this maximum was not attained, in consequence of interruption by clouds passing, when it was usual to heat the solar thermometer artificially to near the stationary point, in order to save time; the great inconvenience of the apparatus in this climate being the slowness with which τ obtained its final value. An arrangement with a differential air-thermometer would, no doubt, be preferable in this respect, but the absolute value of the degrees indicated does not seem capable of being exactly determined.

The thermometers were carefully graduated and compared by myself, and the divisions between two fixed points, 60° and 100° (which included all the observed temperatures), were drawn as nearly equal as a good ivory scale and magnifying lens would admit. The length of a degree on the scale of τ was about .05 inch, and upon x .067 inch; with practised eye it was easy to read off the temperature to $\frac{1}{20}$ th of a degree with lens; but such accuracy was unattainable for other reasons, and chiefly a sensible difference was caused by the varying amount of the stem that was under the influence of the Sun's rays as it moved.

The observations taken on the morning of the 21st August continuously, during $2\frac{1}{2}$ hours of uninterrupted sunshine, were graphically equalised, the curve drawn and ordinates measured off at every 20 minutes. This was the only opportunity that occurred of continuous observation between such favourable

limits of altitude as to indicate the direction of a line with some precision.

In the table of observations, given in the Appendix, the date and apparent time are given in the first column. The time-piece was regulated daily by the one o'clock signal-gun. The second column contains the values of r , the observed difference between thermometers x and y . The film of talc that was interposed between the Sun and x was found to reflect $\frac{2}{30}$ th of the incident rays. This ratio was determined by observations taken with the film off during calm weather. The value of r without the film to r with the film on, was as 1.18 to 1.00; the sun's power not sensibly varying during the interval. This proportion was maintained at low values of r , and even when the source of radiation was a gas-flame. The third column contains the observed values of r increased in this ratio. The fourth column contains the corrections required to reduce the values in the third to a vacuum. The correction is taken from a scale that was constructed by means of an empirical formula derived from observations on the cooling of x , as detailed in the Appendix. The fifth column is the final value of r as it would appear in a naked vacuum, that is, a vacuum without any interposed transparent solid between the Sun and the bulb of the thermometer. The numbers in this column represent the quantity of heat-force supplied from the Sun to the bulb of the thermometer in a constant element of time, or the quantity that emanates from the bulb in a unit of time.

The experiments on the cooling of the thermometer, x , in a vacuum, show that from $r = 30^\circ$ to $r = 15^\circ$, the time of cooling was 294 beats of a time-piece, of which $77\frac{1}{2}$ were equal to 60 seconds; also from $r = 15^\circ$ to $r = 7\frac{1}{2}^\circ$, the time was the same, and generally from $r = 2m$ to $r = m$ the elapsed time is the constant 294, which thus represents the logarithm of 2 in the logarithmic curve, of which the ordinates are r and the abscissæ the time of cooling, t . The equation of the curve being $c \log \frac{r_1}{r_0} = t_1 - t_0$, in which $c \log 2 = 294$, or to reduce to seconds, $c \log 2 = 294 \times \frac{60}{77\frac{1}{2}}$, and $c = 756.1$. Let $t_1 - t_0 = \delta t$, then $\log \frac{r_1}{r_0} = \frac{1}{\mu} \cdot \frac{\delta r}{r}$, in which $\mu = \text{hyp. log of } 10$; hence

$$\frac{c}{\mu} \cdot \frac{\delta r}{r} = \delta t \quad [\log \frac{c}{\mu} = 2.51636].$$

From this we may compute the quantity of heat supplied to a unit of surface by the Sun in a unit of time corresponding to any value of r . As an example, suppose $r = 10^\circ$ and $\delta t = 1$ second, then $\delta r = \frac{10\mu}{c} = 0.030453$, or 3.0453 in 100 seconds, is the rate at which the Sun communicates heat to a thermometer, whose bulb is a sphere 0.42 inch in diameter, when $r = 10^\circ$.

Suppose the glass of the bulb to be $\frac{1}{50}$ th of an inch thick, there would be $\cdot 0108$ cubic inch glass and $\cdot 0287$ cubic inch mercury heated $3^{\circ}\cdot 045$ in 100 seconds. If $r = 20^{\circ}$, the same heating would take place in 50 seconds, and so on.

To reduce this to thickness of ice melted in 1 minute, we have

Specific heat of mercury $\cdot 033$ and of glass $\cdot 177$.

Specific gravity of mercury $13\cdot 5$ and of glass $2\cdot 9$.

$\cdot 0108$ cubic inch glass equal in weight to $\cdot 0313$ cubic inch water.

$\cdot 0287$ cubic inch mercury equal in weight to $\cdot 387$ cubic inch water.

$\cdot 0108$ cubic inch glass raised $3^{\circ}\cdot 045$ takes as much heat as $\cdot 0313$ cubic inch water raised $0^{\circ}\cdot 54$.

$\cdot 0287$ cubic inch mercury raised $3^{\circ}\cdot 045$ takes as much heat as $\cdot 387$ cubic inch water raised $0^{\circ}\cdot 101$.

$\cdot 0313$ cubic inch water raised $0^{\circ}\cdot 54$ takes as much heat as is required to raise 1 cubic inch $0^{\circ}\cdot 0169$.

$\cdot 387$ cubic inch water raised $0^{\circ}\cdot 101$ takes as much heat as is required to raise 1 cubic inch $0^{\circ}\cdot 0391$.

The entire bulb of the thermometer thus raised $3^{\circ}\cdot 045$ is thus equal to 1 cub. in. of water raised $\cdot 0169 + \cdot 0391 = 0^{\circ}\cdot 056$.

Now, the transverse section of bulb is $0\cdot 138$ square inch; and since specific gravity of ice is $0\cdot 93$, and it requires 140° to melt ice, we have $140 \times 0\cdot 738 \times 0\cdot 93 \times x = 3\cdot 045$; hence $x = 0\cdot 00312$ inch, the thickness of ice melted by the Sun in 100 seconds, when $r = 10^{\circ}$. This is equivalent to $0\cdot 001872$ inch in 1 minute. With $r = 20^{\circ}$ the thickness would be double this amount, and so on. Thus the presumed extra atmospheric value of r being 67° gives $0\cdot 0124$ inch thickness melted per minute.

From June to December the amount may be expected to vary $\frac{1}{15}$ th, corresponding to alteration of Sun's distance. In Herschel's *Meteorology* the probable thickness is stated to be $\cdot 0109$ inch.

If the law indicated by straight lines on the chart is true it would require extremely accurate observations to give the extra atmospheric constant of solar radiation with precision. From a single observation made in Bombay some years ago I am disposed to believe it may exceed 67° considerably.

The mode of approaching the law of absorption is as follows:—Project the values of r as ordinates to the secants of zenith distances as abscissæ. The resulting curve is evidently hyperbolic in character. If it is the conic hyperbola, the reciprocals of the ordinates laid off to the same abscissæ should range in a straight line. The obvious plan is, therefore, to lay off the reciprocals of r in this way, and see how far their range agrees with the straight, and, if it differs, the character of the

divergence might lead us to the true function that expresses the natural law, if it was not very complicated, and if the condition of the atmosphere did not vary so rapidly as to obscure it.

The observations, though taken under unfavourable conditions, favour the simple hyperbola.

It will be remarked, on inspecting the chart, that the value of r at the same altitude of the Sun diminishes with the declination as the season advances. If continuous observations were possible for a few hours each day, when the altitude of the sun ranged between 15° and 45° , we might expect to see the projection of the equalised observations range each day in a different line; but these lines ought all to converge on nearly the same point in the ordinate at the zero of the secant scale, if the law holds good. The lines A C, A D, A E, will exemplify this.

Let N, fig. 3, be the position of the observer, z his zenith, and ns the direction of the sun. Draw parallel lines ab, cd , &c.; now $ac : bd :: \text{rad.} : \text{sec.}$ sun's zenith distance, so that the thickness of each stratum varies as the secant; and if the physical condition of the stratum did not alter between two observations, we may take the secant as the representative of the collective thickness of the absorbing medium traversed by the Sun's rays, except at such low altitudes when the curvature of the earth as well as refraction may be expected to introduce uncertainty. The minimum value of the secant is radius, but we may imagine the Sun's rays to pass through a similarly constituted atmosphere in which the thickness of the same layers proportionally diminishes from unity or radius to zero. The reciprocal of r diminished for values below radius at the same rate as for values above radius, attains at zero the extra atmospheric limit which, in all climates and seasons, ought to be determined by the inverse square of our planet's distance from the Sun in its orbit, and should not vary beyond $\frac{1}{30}$ th of its mean value.

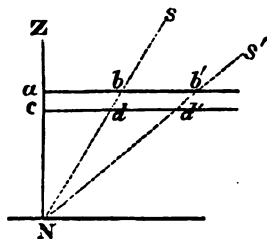


Fig. 3.

Let m_0, m_1 , be the secants at which the radiation is r_0, r_1 , we have, according to the projection $\frac{m_0 - m_1}{\frac{1}{r_0} - \frac{1}{r_1}} = k$, a constant

quantity, so long as the physical condition of the atmosphere remains constant; and to find R, the extra atmospheric value of r , we have

$$m_0 - m_1 : \frac{1}{r_0} - \frac{1}{r_1} :: m_1 : \frac{1}{r_1} - \frac{1}{R}.$$

Hence $m = \frac{k}{r} - \frac{k}{R}$ and $\frac{1}{R} = \frac{1}{r} - \frac{m}{k}$. Since R is constant, we may put $\frac{k}{R} = e$, so that $r = \frac{k}{m+e}$. This expresses the presumed law of absorption or interception.

The essential nature of this law is seen by studying the proportionate differential of r ,

$$-\delta r = \frac{k \delta m}{(m+e)^2} \text{ and } \frac{-\delta r}{r} = \frac{\delta m}{m+e} = \delta m \frac{r}{k}; \text{ hence } \frac{-\delta r}{\delta m} \propto r^2.$$

Thus the Sun's rays, in passing through a constant element of the thickness of the atmospheric medium, loses a proportionate amount of its power that is not constant, but that diminishes in the simple ratio of that power.

As an example, suppose with $r = 30^\circ$, the value diminishes 1° in passing through 1 mile, it would only lose $\frac{1}{9}$ in passing through the same mile if $r = 15^\circ$, and $\frac{1}{100}$ th of a degree if $r = 1^\circ$. We might thus expect, when the atmosphere is clear, it does not intercept any sensible proportion of the heat radiated from the earth's surface into space.

Compare the value of r with one Sun and with two; the supply from each, supposed equal, doubles the value of r , which, measured at the extremities of the mile nearest and furthest from them, shows that for the same element of the thickness of the medium the proportionate decrement of r is constant. Let α represent the angular space occupied by the Sun's disk, and t the potential temperature of its radiating surface, then $t\alpha$ represents the supply of heat by radiation from it upon a unit surface, and is measured by r , so that if αt becomes $2\alpha t$, r becomes $2r$. Now, the factor 2 may have reference to α , the magnitude of the Sun's disk, or it may have reference to t , its temperature. The fluctuating value of r from change of altitude or climate represents a fluctuating potential value of αt , but α being constant, the change is similar to what would take place above the atmosphere by a change in t alone. At different parts of the earth's orbit the value of α changes, so that with t constant and α variable the proportionate absorption represented by $\frac{\delta r}{r \delta m}$ is a constant quantity, but so far as r depends on t the value $\frac{\delta r}{r \delta m}$ increases with t , and the causal relation may be expressed as follows:—

The heat-pulse travels, carrying with it an intensity that it borrows from the temperature of its source, and encounters a deflecting or absorbing power in passing through a constant element of the atmospheric medium that is exactly proportional to that intensity.

It would be simpler if the resistance was uniform,—if the proportion of force absorbed was constant; but the observations do not admit of the possibility of this. The curve traced out

by the co-ordinates, r and secant zenith distance, would in that case be no longer the conic hyperbola, but the logarithmic curve.

At 6 o'clock in the evening of the 31st July, while making an observation, an extensive shower of thin rain took place overhead and westward towards the Sun, without sensibly obscuring its light or affecting its image when examined through a telescope. The value of r descended immediately from 15° to 13° . The single observation I took in India, compared with those taken at the same altitude in this country, indicates that the value of r is there fully double what it is here, while the quantity of vapour held in suspension estimated from the dew-point is certainly greater. It would seem probable, therefore, that the absorbing power of the atmosphere depends on the watery particles contained in it, not upon the aqueous vapour dissolved in it.

[The Appendix, received simultaneously with the foregoing, will appear in the following number of the *Notices*.—Ed.]

26 *Royal Crescent, Edinburgh, Nov. 25, 1861.*

Explanation of the figures.

Fig. 1. T, U, B, E, is a square tube of brass, mounted with motion in altitude upon an upright, R, fixed into a round slab of lead. The inner surface of this tube is blackened, and at each end, at l and c , a film of transparent talc was stuck on to prevent the wind from moving the air within the tube.

H, D, D, H, a double screen made of cardboard and cork, coated on both sides with tin-foil, and fitted to slip on the extremity of the tube presented towards the sun.

m , the hole in centre of screen, about $\frac{1}{10}$ th inch greater diameter than the bulb of the solar thermometer, x.

The talc film, l , was also coated with tin-foil except the central circle.

x, the thermometer in sun with spherical bulb fixed in a cork that fitted the hole, L, L, in top of brass tube.

y, the thermometer in the shade fixed in the hole, n, n, with cork and soft wax as shown.

z, a thermometer applied to outer surface of tube.

Fig. 2 is a transverse section of vacuum bath, employed to ascertain the rate of cooling of the solar thermometer, x, in air and in vacuo.

It consists of a cylindrical vessel of brass, coated internally with lamp-black; the lid, L, is ground to the upper edge of the cylinder, and in its centre is a stuffing box, s, with Indian-rubber collar, through which the stem of the thermometer is passed, as shown in the figure; c, is a stop-cock, upon which, n, the nozzle of a flexible tube communicating with an air-pump, is ground air-tight. H is a wooden handle for removing the apparatus to and from the bath without touching the metal.

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MONTHLY NOTICES
OF THE
ROYAL ASTRONOMICAL SOCIETY.

VOL. XXII.

Jan. 10, 1862.

No. 3.

Dr. LEE, President, in the Chair.

The Rev. Thomas Pyne, Hook, near Kingston-on-Thames;
James McDowell, Esq., Perse Grammar School, Cambridge;
William Wray, Esq., 25 Torriano Terrace, Kentish Town;
C. H. Lake, Esq., Oxford House, King's Road, Chelsea;
Signor Julian Vertu, Lincoln;
John Kidd, Esq., Sherborne, Dorset; and
James Breen, Esq.,

were balloted for and duly elected Fellows of the Society.

An Account of Experiments on Solar Radiation.—Appendix describing the Method employed to discover the Influence of the Air in the Cooling of the Sun Thermometer X., and of Ascertaining the Correction required to be Applied to Observations of r, so as to reduce them to a Vacuum. By John James Waterston, Esq.

Fig. 2* is an upright section of the little apparatus or vacuum-bath. It consists of a cylindrical vessel of brass

* See last number of the *Notices*: the scale is 1 in. = 4 in.—Ed.

coated internally with lamp-black. The lid was ground air-tight to the upper edge, and had a stuffing-box in the centre, through which the stem of the thermometer was passed. A stop-cock enabled a communication to be made with an air-pump. With a plentiful supply of lard to the stuffing-box and ground surfaces, a good vacuum could be maintained for a day unimpaired.

The time was measured by the beats of a clock: to register the number of these at each degree as the mercury of the thermometer descended, a scale of equal parts was prepared extending to 1000, and with distinguishing marks at each 5, 10, 50, and 100. Then with a pencil in the right hand over the scale and a magnifying glass in the left over the scale of the thermometer, I counted the beats, and when the mercury came to the line of a degree, made a mark on the scale of equal parts opposite the number of beats, and at the same time continued to count on; *e. g.* if 57 was the number when the mercury came to a line, a pencil-mark was made at 57 on the scale of equal parts, and the counting went on,—58, 59, &c. until the mercury came to the next line.

Thus, not a beat was lost from beginning to end, and the accuracy was only limited by the accuracy of the divisions on the scale of the thermometer. Indeed, this method is a severe test to the equality of the divisions, because the reciprocal of the differences in the number of the beats for each degree, if laid off as ordinates to the total number of beats, ought to range in a straight line, and any saw-like irregularities indicate inaccuracy in the divisions of the scale of the thermometer. To heat the bulb of the thermometer a funnel was placed over the small flame of a Bunsen; then holding the plate (having the thermometer fixed in its place) by means of the stop-cock, the bulb was brought over the top of the funnel until the mercury had risen to near the top of the scale. The plate was then quickly placed on the cylinder, communication made with the air-pump, and the air exhausted from the cylinder by 20 strokes, the capacity of the pump being about one-third that of the cylindrical vessel or vacuum-bath. The vessel thus exhausted was placed in a water-bath, the temperature of which was ascertained at the beginning and end; the difference seldom amounting to $\frac{1}{10}$ th of a degree.

The following table exhibits two series of observations on the cooling of the sun thermometer, x , in the vacuum, and in air taken while the water-bath remained steady at 48° . This basal temperature being at an exact degree enables the rate of cooling to be studied easily without fractional parts or interpolation:—

Temp. X.	Beats in Vacuum.	r.	Beats in Air.	Temp. X.	Beats in Vacuum.	r.	Beats in Air.
90°		42°	0	90°		42°	
85°	0	37°	36	65°	323	17°	270
4	12	36		4	348	16	291
3	24	35		3	377	15	312
2	36	34		2	406	14	336
1	48	33		1	437	13	360
80	60½	32	78	60	470	12	385
9	73	31		9	510	11	414
8	86	30		8	549	10	448
7	100½	29		7	594	9	484
6	115	28		6	643	8	527
75	130½	27	129	55	704	7	576
4	145½	26		4	765	6	630
3	161	25		3	843	5	695
2	179½	24		2	...	4	780
1	197	23		1	...	3	
70	214	22	191	50	...	2	
9	235	21		9	...	1	
8	255	20		48	...	0	
7	276	19					
6	298	18					

Thus, 53, being the last observation of the vacuum cooling, corresponds with $r = 5^\circ$; then

At $r = 5$ we have 843 beats	Difference 294	
$r = 10$ " 549 "	" 294	Mean Difference 291.7
$r = 20$ " 255 "	" 287	
$r = 40$ " -32 "		

Again, beginning with $r = 7^\circ$,

At $r = 7$ we have 704 beats	Difference 298	
$r = 14$ " 406 "	" 291	Mean Difference 294½
$r = 28$ " 115 "		

And beginning with $r = 9$,

At $r = 9$ we have 594 beats	Difference 296	
$r = 18$ " 298 "	" 286	Mean Difference 291
$r = 36$ " 12 "		

The numbers in the column of differences ought to be the same if the law of cooling in a vacuum is perfectly true, if the vacuum is complete, and if the graduation of the thermometer is correct. The difference between them is so small that the result must, I think, be deemed satisfactory.

Let us study the same differences with the cooling in air:—

At $r = 5^\circ$ we have 695 beats				1st Difference 247	
$r = 10$	"	448	"	"	2d Difference 19
$r = 20$	"	220	"	"	" 22
$r = 40$	"	14	"	"	
$r = 7^\circ$ we have 576 beats				1st Difference 240	
$r = 14$	"	336	"	"	2d Difference 23
$r = 28$	"	119	"	"	
$r = 9^\circ$ we have 484 beats				1st Difference 230	
$r = 18$	"	254	"	"	2d Difference 20
$r = 36$	"	44	"	"	

Thus, it appears that in air the cooling takes place in a ratio greater than r , the 1st difference of the times diminishing and the 2d difference slightly increasing between 247 and 210. The limiting value of the 1st difference must be 294 when $r = 0$, and 294 minus the 1st difference increases nearly as $\sqrt{r}$. An empirical formula constructed in conformity with this ratio cannot differ much from the observations.

Let Δ represent 1st difference and g a constant,

$$\Delta = 294 - g \sqrt{r} \quad \text{and} \quad g = \frac{294 - 247}{\sqrt{7\frac{1}{2}}} = 17.162 = \frac{294 - 210}{\sqrt{27}} = \&c. \text{ (nearly).}$$

Δ represents the logarithm of 2, so that c being a constant, we have $\log r = \frac{\Delta}{c}$. In the curve that represents the cooling in air we may assume a small arc of it to coincide with a true logarithmic curve or the curve of cooling in a vacuum, and we have to find the value of r , the ordinate of the true logarithmic curve at the given point.

The logarithmic curve is defined by the equation

$$c \log \frac{r_1}{r_0} = t_1 - t_0 = \frac{\Delta}{\log 2} \log \frac{r_1}{r_0}.$$

Let

$$r_0 = (r_1 - 0.001).$$

To find the value of r_v corresponding to a given r_a (r_v vacuum, r_a air), we require to compute the value of $t_1 - t_0$, employing $\Delta_a = 294 - g \sqrt{r}$ in the equation

$$\frac{\Delta_a}{\log 2} \log \frac{r_a}{(r_a - 0.1)} = t_1 - t_0;$$

then, with this value of $t_1 - t_0$, and with $\Delta_v = 294$, find the value of r_v in the equation

$$t_1 - t_0 = \frac{\Delta_v}{\log 2} \cdot \log \frac{r_v}{(r_v - 0.1)}.$$

The direct equation is

$$\Delta_a \{ \log r_a - \log (r_a - 0.1) \} = \Delta_v \{ \log r_v - \log (r_v - 0.1) \}$$

and

$$\frac{\Delta_a}{\Delta_v} = 1 - \frac{g}{294} \sqrt{r_a} = 1 - \frac{\sqrt{r_a}}{17.131}.$$

Hence r_v may be ascertained by inspecting the differences of a table of logarithms; and it was from these that a scale was constructed for reducing the values of r taken in air to what they would be if taken in a vacuum, where the emission of heat was by radiation alone.

The cooling of the sun thermometer in air when fixed in its place in the tube, as in fig. 1, was found to be exactly the same as when fixed in the cylinder, fig. 2, unexhausted.

A chemical thermometer with cylindrical reservoir was tried in the vacuum-bath, and the cooling was found to take place exactly in the logarithmic curve. It is difficult to adjust the vacuum-bath in time to observe a high value of r , but good observations were obtained from $r = 190^\circ$ downwards; so there is little doubt that the law of cooling by radiation is general and independent of the shape of the cooling body. I purpose extending these observations with different surfaces. One result is interesting, as showing the perfect reciprocity of the radiation, viz. a gilt bulb radiating against a blackened metallic surface loses heat at the same rate as a blackened bulb against a bright metallic surface; the rate being slower than when both are blackened.

Another fact that it is well to keep in view is that, although the uncoated glass bulb radiates as quickly as the same coated with black, it does not absorb the incident rays of heat to the same degree; nearly one half being reflected without entering the glass.

Observations on Solar Radiation.

1861.	Apparent Time.		Observed Values of r .	Ditto corrected for Talc Film.	Correction to Reduce to a Vacuum.	Value of r Reduced to a Vacuum.	$\frac{1}{r}$ = Reciprocal of Ditto.	Apparent Altitude of Sun's Centre.	Coscent of Apparent Zenith Distance.	Remarks
	h	m	r_o	r_a	p	r_v	$\frac{1}{r_v}$	App. Alt.		
July 28	4 25 P.M.		17.5	20.6	+7.4	28.0	.0357	28 49	2.075	Bulb coated with lamp-black and turpentine; surface moist.
	4 36		16.5	19.5	6.8	26.3	.0380	27 16	2.183	
	4 56		15.5	18.3	6.2	24.5	.0408	24 30	2.411	
	5 26		14.0	16.5	5.2	21.7	.0461	20 19	2.880	
	6 18		13.2	15.5	4.7	20.2	.0495	13 11	4.385	
	7 26		7.2	8.5	1.7	10.2	.0980	4 27	12.888	
	30 6 36 P.M.		11.8	13.9	+3.9	17.8	.0562	10 41	5.394	
31	6 45		10.8	12.7	3.3	16.0	.0625	9 12	6.255	Extra favourable conditions. Ditto.
	7 13		6.6	7.8	1.4	9.2	.1087	5 44	10.010	
	Noon		23.0	27.2	+11.4	38.6	.0259	52 20	1.263	
	5 41 P.M.		15.0	17.7	5.8	23.5	.0425	17 38	3.301	
	6 6		14.0	16.5	5.2	21.7	.0461	14 3	4.119	
	6 29		13.0	15.3	4.6	19.9	.0502	11 6	5.194	
	7 18		9.0	10.6	2.5	13.1	.0763	4 36	12.47	
Aug. 1	9 51 A.M.		20.5 + 24.2		+9.5	33.7	.0297	44 58	1.415	From July 31, to Aug. 5, the bulb coated with China ink and gum turpentine; surface
	4 11 A.M.		20.0	23.6	9.1	32.7	.0306	49 35	1.313	
	6 36 P.M.		11.3	13.4	3.6	17.0	.0588	9 15	6.221	
B {	5 Noon		20.2	23.8	9.2	33.0	.0303	51 0	1.287	Extra favourable conditions. Bulb uncoated. Ditto.
	3 44 P.M.		11.3	13.3	3.6	16.9	.0592	33 14	1.825	
	4 30		9.7	11.4	2.7	14.1	.0709	27 10	2.190	

All the above, taken with thermometer Y in the sun, and its correction for air, has been assumed to be the same as that experimentally determined for thermometer X in the subsequent observations.

In the following observations the thermometer in sun was X, with bulb coated with China ink:—

1861.	h	m	r_o	r_a	p	r_v	$\frac{1}{r_v}$	App. Alt.	coscent.	
Aug. 9	3	34 P.M.	14.4	17.0	+5.5	22.5	.0444	33 7	1.830	
10	8	50 A.M.	15.2	17.9	+5.9	23.8	.0420	35 56	1.704	Taken from consecutive 18 observations
	9	8	15.5	18.3	6.1	24.4	.0410	38 5	1.621	
	9	23	16.2	19.1	6.6	25.7	.0389	39 48	1.562	

1861.	h	m	r_0 °	r_a °	p °	r_v °	$\frac{1}{r_0}$	App. Alt. °	cosc.	
13	4	56 P.M.	12.8	15.1	+4.5	19.6	.0510	21 1	2.787	Not less, perhaps greater value of r .
	6	56	4.8	5.7	0.9	6.6	.1515	4 37	12.42	
	7	27	2.2	2.6	0.3	2.9	.3448	0 53		
										Sunset.
15	6	1 P.M.	9.5	11.2	2.7	13.9	.0719	11 25	5.05	
	7	4	3.8	4.5	0.6	5.1	.1961	3 4	18.69	
16	5	16 A.M.	4.4	5.2	0.8	6.0	.1667	5 29	10.465	Sun rises perfectly clear of clouds.
	9	39	14.6	17.2	5.6	22.8	.0439	39 51	1.561	
	11	3	15.0	17.7	5.8	23.5	.0425	46 20	1.382	
21	7	20 A.M.	9.8	11.6	2.9	14.5	.0690	19 0	3.071	Consecutive series graphically projected and equalised.
	7	40	10.7	12.6	3.3	15.9	.0629	21 45	2.698	
	8	0	11.6	13.7	3.8	17.5	.0571	24 29	2.413	
	8	20	12.3	14.5	4.2	18.7	.0535	27 9	2.191	
	8	40	13.0	15.3	4.6	19.9	.0502	29 45	2.015	
	9	0	13.5	15.9	4.9	20.8	.0481	32 14	1.874	
	9	20	13.8	16.2	5.0	21.2	.0472	34 37	1.760	
	9	40	14.1	16.6	5.3	21.9	.0457	36 50	1.668	
20	6	21 16 P.M.	6.6	7.7	+1.4	9.1	.1099	7 21	7.817	Consecutive series not equalised.
	6	23 16	6.5	7.6	1.4	9.0	.1111	7 4	8.128	
	6	24 31	6.4	7.5	1.4	8.9	.1124	6 55	8.304	
	6	26 16	6.1	7.2	1.3	8.5	.1177	6 41	8.592	
	6	27 16	6.0	7.1	1.2	8.3	.1205	6 33	8.767	
	6	28 36	6.1	7.2	1.3	8.5	.1177	6 22	9.018	
	6	31 0	5.7	6.7	1.1	7.8	.1282	6 2	9.514	
	6	37 16	4.8	5.7	0.8	6.5	.1538	5 12	11.034	
	6	39 0	4.7	5.6	0.8	6.4	.1562	4 59	11.512	
Small cloud passes over the sun.										
	6	43 56	3.4	4.0	0.5	4.5	.2207	4 22	13.134	
	6	45 46	3.3	3.9	0.5	4.4	.227	4 5		
	6	47 16	3.2	3.8	0.5	4.2	.235	3 54		
	6	49 16	3.0	3.6	0.5	4.0	.249	3 38		
	6	51 0	2.8	3.3	0.4	3.7	.272	3 25		
	6	52 16	2.7	3.1	0.3	3.5	.287	3 15		
	6	54 0	2.4	2.9	0.3	3.2	.312	3 2		
	6	55 45	2.2	2.6	0.3	2.9	.348	2 48		
	6	58 46	1.9	2.2	0.2	2.4	.408	2 30		
	7	1 16	1.6	1.9	0.2	2.1	.483	2 7		
	7	4 0	1.1	1.3	0.1	1.4	.714	1 48		
28	Noon	12.5	14.8	4.3	19.1	.0524	43 42	1.447		
	0 44 P.M.	13.2	...	...	...	...	...	...	...	r sensibly augments after culmination.

In the following, thermometer τ was in sun, with its bulb coated with lamp-black in gold size:—

			r_0	r_1	p	r_2	$\frac{1}{r_0}$	App. Alt.	cos θ .
1861.	^h	^m	[°]	[°]	[°]	[°]		[°]	
Aug. 6	8	7 A.M.	16.2	19.1	6.6	25.7	.0389	31 17	1.926
	9	8	18.0	21.2	7.7	28.9	.0346	42 21	1.484
	9	32	18.3	21.6	8.0	29.6	.0338	45 12	1.409

Note.—Referring to the method of computing the Sun's potential temperature, described in the proceedings of the Society for March 1860, and employing the same rule with R , the extra atmospheric value of r equal to 70° at Earth's mean distance, we arrive at $12,880,000^\circ$ as the potential temperature of its radiating surface.*

If we expose the flame of a bat's-wing-jet to one ball of a differential thermometer, the effect is the same, whether the broad side or the narrow side of the flame is presented, as I have found on trial. Now the potential temperature being equal to the product of r by the reciprocal of the angular space occupied by the flame, it is in the one case about five times greater than in the other. In the same way we might compute the potential temperature of an angular space occupied by many thousand flames placed one behind the other, extending in a line from the observer, and probably we should find it cumulative in the ratio of the number of flames.

From observations I have made on gas flames with the radiation meter, fig. 1, it would seem to require about 4000 bat's-wing-flames ranged behind each other to give a potential equal to that of the Sun.

If the upper radiating matter of the Sun is in any degree transparent or permeable to radiation from lower strata, it is obvious that the *actual* temperature may thus be much below the *potential*.

26 Royal Crescent, Edinburgh, November 25, 1861.

Note on a Theorem of Jacobi's, in relation to the Problem of Three Bodies. By A. Cayley, Esq.

The following theorem of Jacobi's (*Comptes Rendus*, t. iii., p. 61 (1836)) has not, I think, found its way in an explicit form into any treatise of physical astronomy. The theorem is as follows, viz. "Consider the movement of a point without mass round the Sun, disturbed by a planet the orbit of which

* There is a typographical error in the *Monthly Notices*, page 201, line 32; for $x = 918000$, read $x = 9,180,000$.

is circular. Let xyz be the rectangular co-ordinates of the disturbed body, the orbit of the disturbing planet being taken as the plane of xy , and the Sun as the centre of co-ordinates; let a' be the distance of the disturbing planet, $n't$ its longitude, m' its mass, M the mass of the Sun: then we have, *rigorously*,

$$\begin{aligned} & \frac{1}{2} \left[\left(\frac{dx}{dt} \right)^2 + \left(\frac{dy}{dt} \right)^2 + \left(\frac{dz}{dt} \right)^2 \right] - n' \left(x \frac{dy}{dt} - y \frac{dx}{dt} \right) \\ &= \frac{M}{(x^2 + y^2 + z^2)^{\frac{3}{2}}} + m' \left\{ \frac{1}{(x^2 + y^2 + z^2 - 2a'(x \cos n't + y \sin n't) + a'^2)^{\frac{3}{2}}} \right. \\ & \quad \left. - \frac{x \cos n't + y \sin n't}{a'^3} \right\} + C. \end{aligned}$$

This is therefore a new integral equation, which, in the problem of three bodies, subsists, as regards the terms independent of the excentricity of the disturbing planet, and which is rigorous as regards all the powers of the mass of such planet. In the *Lunar Theory* the Earth must be substituted in the place of the Sun, and the Sun taken as the disturbing planet."

To prove the theorem, as expressed in polar co-ordinates, I take the equations of motion in the form in which I have employed them in my "Memoir on the Theory of Disturbed Elliptic Motion" (*Memoirs*, vol. xxvii. p. 1 (1859)), viz.

$$\frac{d}{dt} \frac{dr}{dt} - r \cos^2 y \left(\frac{dv}{dt} \right)^2 - r \left(\frac{dy}{dt} \right)^2 + \frac{n^2 a^2}{r^3} = \frac{d\Omega}{dr},$$

$$\frac{d}{dt} \left(r^2 \cos^2 y \frac{dv}{dt} \right) = - \frac{d\Omega}{dv},$$

$$\frac{d}{dt} \left(r^2 \frac{dy}{dt} \right) + r^2 \cos y \sin y = - \frac{d\Omega}{dy},$$

where

$$\Omega = m' \left\{ \frac{1}{\sqrt{r^2 + r'^2 - 2rr' \cos H}} - \frac{r \cos H}{r'^3} \right\};$$

or, since $\cos H = \cos y \cos (v - v')$, and the Sun is considered as moving in a circular orbit (i.e. $r' = a'$, $v' = n't$), we have

$$\Omega = m' \left\{ \frac{1}{\sqrt{r^2 + a'^2 - 2ra' \cos y \cos (v - n't)}} - \frac{r \cos y \cos (v - n't)}{a'^3} \right\};$$

so that Ω is a function of r, v, y and of t , which last quantity enters only in the combination $v - n't$. Hence the complete differential coefficient of Ω is

$$\frac{d(\Omega)}{dt} = \frac{d'\Omega}{dt} - n' \frac{d\Omega}{dv},$$

where $\frac{d'\Omega}{dt}$ denotes, as usual, the differential coefficient in regard to the time, in so far as it enters through the co-ordinates r, v, y of the disturbed body.

We have, as usual,

$$\frac{d}{dt} \frac{dr^2 + r^2 (\cos^2 y dv^2 + dy^2)}{dt^2} = \frac{d'\Omega}{dt};$$

but from the foregoing equation,

$$\begin{aligned} \frac{d'\Omega}{dt} &= \frac{d(\Omega)}{dt} + n' \frac{d\Omega}{dv} \\ &= \frac{d(\Omega)}{dt} + n' \frac{d}{dt} \left(r^2 \cos^2 y \frac{dv}{dt} \right); \end{aligned}$$

and, substituting this value, transposing, and integrating, we have

$$\left(\frac{dr}{dt} \right)^2 + r^2 \left\{ \cos^2 y \left(\frac{dv}{dt} \right)^2 + \left(\frac{dy}{dt} \right)^2 \right\} - n' r^2 \cos^2 y \frac{dv}{dt} = \Omega + C,$$

which is Jacobi's equation expressed in terms of the co-ordinates r, v, y .

M. de Pontécoulant, in his *Lunar Theory* (1846), where the solar excentricity is neglected, writes (p. 91),

$$\int d'R = R + m \int \frac{dR}{dv} dt,$$

($n' = m n = m$, since n is there put equal to unity); and combining this with the equation (p. 43),

$$\frac{r^2 dv}{(1 + e^2) dt} = h + \int \frac{dR}{dv} dt,$$

we have

$$\int d'R = R - m h + \frac{m r^2 dv}{(1 + e^2) dt};$$

and substituting this value of $\int d'R$ in the integral of *Vis Viva* (p. 41),

$$\left(\frac{dr}{dt}\right)^2 + \frac{r^2 dv^2}{(1+s^2) d\theta^2} + \frac{r^2 ds^2}{(1+s^2)^3 d\theta^2} - \frac{2}{r} + \frac{1}{a} = 2 \int d'R,$$

we have what is, in fact, Jacobi's equation.

A Third Memoir on the Problem of Disturbed Elliptic Motion.

By A. Cayley, Esq. (Abstract.)

The object of the Memoir is to obtain the differential equations for determining

r , the radius vector,

v , the longitude,

y , the latitude,

of the disturbed body, when the last two co-ordinates are measured in respect to an arbitrarily varying plane (which, however, to fix the ideas, is called the variable ecliptic) and departure-point, or origin of longitudes therein. This is very readily effected by means of an expression for the *Vis-Viva* function given in my "Supplementary Memoir on the Problem of Disturbed Elliptic Motion," *Mem. Roy. Ast. Soc.*, vol. xxviii. pp. 217-234 (1859).

Neglecting the squares of the variations of the variable ecliptic, and also the products of the variations by $\sin y$ or $\frac{dy}{dt}$, then (as might be expected) it is found that the equations for r and v are the same as for a fixed ecliptic, and the equation for y is found in a simple form, which is ultimately reduced to coincide with that obtained for the lunar theory by Laplace in the seventh book of the *Mécanique Céleste*, and which is used by him to show that the effect of the variation of the ecliptic on the latitude of the Moon (as measured from the variable ecliptic) is insensible. And it is shown conversely how the approximate formula of the Memoir may be obtained by a process similar to that made use of in the *Mécanique Céleste*.

On the Circularity of the Sun's Disk. By G. B. Airy, Esq.,
Astronomer Royal.

It has been proposed lately to prepare an apparatus for the purpose of examining whether the Sun's disk is really circular, and, in particular, for ascertaining whether the diameters nearly perpendicular to the ecliptic are equal to those nearly parallel to the ecliptic. I would not by any means discourage the trial of such apparatus, but I would unhesitatingly express my opinion that the result of the trial would be to show whether the apparatus is or is not trustworthy, and not to give any new information regarding the measure of the Sun's diameters in any degree comparable to that which we already possess.

Perhaps few persons except professional astronomers are aware of the enormous amount of evidence which already exists in reference to the values of the Sun's diameters, and of the way in which this evidence is growing every day in the ordinary routine of meridional observations. To make this fully understood, I will here explain what is prepared in the *Nautical Almanac*, what is observed at the Royal Observatory, how the observations are reduced, and how the comparison of the reduced observations with the numbers of the *Nautical Almanac* bears upon the subject now before us.

For the calculations of the *Nautical Almanac*, an assumption is made as to the numerical value of the Sun's diameter, as seen when the Earth is at its mean distance from the Sun. It matters not whether this assumed diameter is or is not correct, provided that it be used consistently in all the calculations of each year; and it matters not whether it be or be not changed from year to year, provided that each volume contain a statement of the assumed diameter which has actually been used in the calculations of that volume. Thus the assumed value of Sun's diameter, as seen at Earth's mean distance, in the *Nautical Almanacs* from 1836 to 1852, was $32' 1''.80$; that in the subsequent *Nautical Almanacs* is $32' 3''.64$.

With the diameter thus assumed, two sets of numbers are computed in the *Nautical Almanac*. One is, the apparent diameter (or semidiameter) of the Sun at noon on every day; this is found by merely altering the assumed diameter in the inverse proportion of the Earth's varying distance from the Sun. The other is, the duration of passage of the Sun's diameter across the meridian, or the measure of the sidereal time which elapses between the passage of the Sun's western limb and its eastern limb; this is found, from the apparent diameter of the day, by introducing the consideration of the Sun's declination, and of the Sun's motion in right ascension. And, these numbers being prepared, it is evident that we have elements which correspond very closely with facts that may be

observed, the elements being essentially based on the supposition that the Sun's disk is circular.

Corresponding to these two classes of computed elements, we have two classes of facts observed at the Royal Observatory and at other Observatories. One is, the zenith distance of the Sun's upper limb and that of the Sun's lower limb. When each of these is corrected separately for refraction and parallax, the true results of geocentric observation are obtained; and the difference between them gives the observed *vertical* diameter of the Sun on the day of observation. The other is, the sidereal time shown by the transit-clock at the instant of transit of the Sun's western limb, and that at the transit of the Sun's eastern limb; the difference between these gives the observed duration of passage of the Sun's *horizontal* diameter across the meridian on the day of observation.

Now if we compare each of these numbers separately (namely, the observed vertical diameter and the observed duration of passage of horizontal diameter) with the corresponding numbers in the *Nautical Almanac*, and if we omit consideration of chance-errors of observation, the effect of which may be supposed to be nearly eliminated in the mean of many observations, the following results ought to hold:—If the Sun's disk is really circular, and if the *Nautical Almanac* assumed diameter at mean distance is correct, then the observed vertical diameter will agree with the *Nautical Almanac* diameter for the day, and the observed duration of passage will agree with that of the *Nautical Almanac*. If the Sun's disk is really circular, but the assumed diameter incorrect, then neither of the compared measures will agree with the corresponding computation of the *Nautical Almanac*; each discordance (one of vertical diameter, the other of duration of passage of horizontal diameter) will indicate a numerical value of correction to be applied to the assumed diameter; but the two numerical values will absolutely agree. But if the Sun's disk is not really circular, then it is impossible that the comparison of observed vertical diameters on the one hand, and of observed durations of passage of horizontal diameters on the other hand, with elements computed on the supposition that the Sun is circular, can indicate the same correction to the assumed semidiameter.

All that is necessary, therefore, for ascertaining whether the Sun's horizontal diameter and the Sun's vertical diameter are equal, is, every day to compare the Sun's observed vertical diameter with the *Nautical Almanac* diameter, and the observed duration of passage of Sun's horizontal diameter with the *Nautical Almanac* duration, and to infer separately from these the correction to be made to the *Nautical Almanac* assumed diameter. If the two results agree, the horizontal and vertical diameters are equal.

Now these comparisons are made every day in the routine of the Royal Observatory, and their results will be found in

one of the late sections of each volume of the printed *Greenwich Observations*, as well as in the more extensively distributed *Results of the Greenwich Observations*, which contain that section; and the means of the numbers for each year are given in the Introduction to each volume. By extracting these numbers, the following table is formed. I have thought it necessary to divide the table into three parts, distinguished by the following circumstances:—From 1836 to 1850, the 4-inch telescope (I believe Dollond's) of the Mural-Circle was used for the vertical diameters, and the 5-inch telescope (Dollond's) of the Transit for the horizontal passages; the diameter used in the computations of the *Nautical Almanac* was $32' 1'' \cdot 80$. Through 1851 and 1852, the 8-inch telescope (Simms') of the Transit-Circle was used for both measures, the *Nautical Almanac* assumed diameter being still $32' 1'' \cdot 80$. From 1853 to 1860, the telescope of the transit-circle was used for both measures, but the *Nautical Almanac* assumed diameter was $32' 3'' \cdot 64$.

Apparent Errors of the Duration of Passage of the Sun's Horizontal Diameter, and of the Sun's Vertical Diameter, as computed in the Nautical Almanac.

Year.	No. of Obs. of Horizontal Diameter.	Mean Value of N.A. — Ob.	No. of Obs. of Vertical Diameter.	Mean Value of N.A. — Ob.
1836	104	—0' 17	116	—1' 50
1837	92	—0' 18	122	—1' 85
1838	108	—0' 14	115	—1' 53
1839	103	—0' 14	114	—0' 94
1840	104	—0' 18	112	—1' 60
1841	102	—0' 14	109	—1' 32
1842	116	—0' 14	121	—1' 54
1843	99	—0' 14	107	—1' 84
1844	102	—0' 18	117	—1' 50
1845	100	—0' 17	113	—1' 32
1846	92	—0' 10	101	—2' 09
1847	89	—0' 05	89	—2' 98
1848	94	—0' 06	102	—2' 06
1849	103	—0' 11	101	—2' 40
1850	94	—0' 11	86	—2' 18
1851	87	—0' 08	106	—0' 71
1852	103	—0' 12	112	—1' 39
1853	78	0' 00	86	+0' 58
1854	109	+0' 09	111	+1' 29
1855	84	+0' 07	93	+0' 65

Year.	No. of Obs. of Horizontal Diameter.	Mean Value of N.A.—Ob.	No. of Obs. of Vertical Diameter.	Mean Value of N.A.—Ob.
1856	104	+0'10	109	+1'17
1857	113	+0'07	123	+0'99
1858	126	+0'07	132	+0'92
1859	109	+0'08	125	+0'99
1860	72	+0'09	72	+1'64

If we take the sums of the numbers of observations and the means of the errors, and if we remark that the mean error of the horizontal diameter in arc may be obtained from the mean error of the duration of passage without sensible error by multiplying by 14, we obtain the following numbers:—

Period.	No. of Obs.	Mean Error of N.A. Duration of Passage.	Mean Error of N.A. Horizontal Diameter.	No. of Obs.	Mean Error of N.A. Vertical Diameter.
1836 to 1850	1502	-0'134	-1'88	1625	-1'78
1851 and 1852	190	-0'100	-1'40	218	-1'05
1853 to 1860	795	+0'071	+0'99	851	+1'03

If we change the signs of these errors, to form corrections, and apply them to the assumed diameter at mean distance of the Earth from the Sun (namely, $32' 1''\cdot80$ to the end of 1852, and $32' 3''\cdot64$ from the beginning of 1853), to produce a corrected diameter of the Sun at mean distance, we form the following table:—

Instruments employed.	Period.	No. of Obs.	Corrected Horizontal Diameter.	No. of Obs.	Corrected Vertical Diameter.
Transit and Mural Circle ...	1836 to 1850	1502	32 3'68	1625	32 3'58
Transit Circle ...	{ 1851 and 1852 }	{ 190 }	{ 32 3'20 }	{ 218 }	{ 32 2'85 }
	{ 1853 to 1860 }	{ 795 }	{ 32 2'65 }	{ 851 }	{ 32 2'61 }
	Mean 1851 to 1860	985	32 2'76	1069	32 2'66

Thus the observations with both classes of instruments, in aggregate number 2487 for horizontal diameter and 2694 for vertical diameter, agree in showing that the horizontal diameter exceeds the vertical diameter by only $0''\cdot1$, a quantity smaller than we can answer for in these or in any other methods of observation.

A consideration of the number and excellence of the observations fully supports the view which I have stated in introducing this subject: that the only result which could be deduced from the trial of new apparatus would be to test the apparatus, but not to add to the certainty of the conclusion as to the equality of diameters.

The diameter adopted now in the *Nautical Almanac* was inferred from observations made with the Transit and Mural Circle, and therefore agrees very closely with that here deduced from the use of those instruments. That obtained with the Transit-Circle is less by $0''.93$.

Royal Observatory, Greenwich,
Dec. 23th, 1861.

Table of Comparative Number of Observations of Small Planets. By the Astronomer Royal.

For my own guidance, in arranging the course of observations of the Royal Observatory, I lately thought it necessary to draw out a Table exhibiting the comparative number of observations of the Small Planets between *Mars* and *Jupiter*, on the one hand, as made at all Observatories (in the aggregate) except that of Greenwich, and on the other hand as made at Greenwich. For this purpose, I fixed upon the year 1858, as the latest for which I might presume all observations to be published; and my Assistant, Mr. Carpenter, examined every record to which I have access. The result may, perhaps, be interesting to the Society.

For Small Planets discovered before the middle of 1857.

Name of Planet.		Number of Observatories.	Number of Observations.		Observatory, Greenwich.	Number of Meridional Observations.
			Equatorial.	Meridional.		
Ceres	(1)	2	0	21	"	22
Pallas	(2)	2	0	12	"	29
Juno	(3)	2	0	24	"	27
Vesta	(4)	3	0	24	"	31
Hebe	(5)	4	0	11	"	19
Iris	(7)	5	14	13	"	21
Flora	(8)	7	13	47	"	23

Name of Planet.	Number of Observa- tories.	Number of Observations. Equa- toreal.	Meri- dional.	Observa- tory, Greenwich.	Number of Meridional Observa- tions.
Metis (9)	1	0	2	"	16
Hygeia (10)	0	0	0	"	1
Parthenope (11)	3	4	10	"	13
Egeria (13)	4	7	8	"	17
Irene (14)	0	0	0	"	6
Eunomia (15)	4	1	29	"	22
Psyche (16)	5	18	7	"	11
Thetis (17)	0	0	0	"	1
Melpomene (18)	5	10	4	"	21
Fortuna (19)	4	6	6	"	22
Massilia (20)	6	14	19	"	21
Lutetia (21)	1	5	0	"	11
Calliope (22)	2	6	2	"	8
Thalia (23)	6	4	16	"	18
Themis (24)	6	25	8	"	7
Phocæa (25)	1	1	0	"	0
Proserpine (26)	5	19	4	"	6
Euterpe (27)	5	6	33	"	16
Bellona (28)	1	34	0	"	0
Amphitrite (29)	5	6	9	"	24
Urania (30)	5	20	6	"	22
Pomona (32)	2	8	0	"	4
Polyhymnia (33)	1	4	0	"	0
Atalanta (36)	1	1	0	"	0
Fides (37)	4	16	0	"	0
Leda (38)	3	10	0	"	2
Lætitia (43)	4	12	11	"	32
Daphne (41)	1	1	0	"	0
Iris (42)	0	0	0	"	2
Ariadne (48)	3	14	0	"	11
Nysa (44)	3	13	1	"	4
Sum		292	327		490

For Small Planets discovered after the middle of 1857.

Name of Planet.	Number of Observatories.	Number of Observations.		Observatory, Greenwich.	Number of Meridional Observations.
		Equatorial.	Meridional.		
Eugenia (45)	3	11	0	"	0
Aglaia (47)	3	20	0	"	0
Doris (48)	2	11	0	"	0
Pales (49)	2	11	0	"	0
Virginia (50)	3	14	0	"	0
Nemausa (51)	5	57	0	"	7
Europa (52)	10	62	17	"	7
Calypso (53)	8	50	0	"	0
Alexandra (54)	6	40	0	"	2
Pandora (55)	7	83	0	"	3
Sum		359	17		19

It appears from this table that the observations made in the first year of a planet's discovery are almost exclusively extrameridional; but that in subsequent years the meridional observations slightly preponderate. And with regard to these (on which probably the accurate theory and even the permanent retention of planets in the list of our solar system will ultimately depend), it appears that a single Observatory of established regularity of system contributes a greater number of observations than the aggregate of all the others. As regards Greenwich, the increase in the number of small planets has now made it necessary to diminish the attention given to each; but it is probable that the ratio for the different Observatories will not be materially altered.

It appears necessary, therefore, that Observatories of fixed system should still retain these bodies in the list of those to be regularly followed. The observations, however, are extremely onerous, and it is much to be wished that they could be somewhat distributed. Hitherto my efforts to effect an arrangement for this purpose have entirely failed.

Royal Observatory, Greenwich.
1861, December 19.

Results of Meridional Observations of Small Planets; and Phenomena of Jupiter's Satellites; observed at the Royal Observatory, Greenwich, during the month of December, 1861.

(Communicated by the Astronomer Royal.)

Victoria (19).

Mean Solar Time of Observation.			R. A. from Observation.	N. P. D. from Observation.
		^h ^m ^s	^h ^m ^s	[°] ['] ["]
1861, Dec.	2	10 0 17.5	2 47 10.45	73 39 49.17
	5	9 46 38.3	2 45 18.73	73 59 10.78
	19	8 46 25.3	2 40 7.65	75 9 7.65

Irene (14).

Mean Solar Time of Observation.			R. A. from Observation.	N. P. D. from Observation.
		^h ^m ^s	^h ^m ^s	[°] ['] ["]
1861, Dec.	2	9 14 48.4	2 1 33.86	87 6 14.49
	5	9 1 34.2	2 0 7.17	87 0 49.32

Europa (22).

Mean Solar Time of Observation.			R. A. from Observation.	N. P. D. from Observation.
		^h ^m ^s	^h ^m ^s	[°] ['] ["]
1861, Dec.	2	7 49 48.3	0 36 19.82	95 34 18.52

All the observations of N. P. D. have been corrected for refraction and parallax.

No occultations of Stars by the Moon were observed.

Phenomena of Jupiter's Satellites.

Day of Observation.	Satellite.	Phenomenon.	Mean Solar Time.	Observer.
			^h ^m ^s	
1861. Dec. 1	III	Ecl. reappearance (a)	14 27 24.3	C.
8	III	Ecl. disappearance	15 6 42.7	R.
8	III	Ecl. reappearance	18 23 34.1	R.
13	IV	Egress first cont. (b)	18 33 29.4	M. D.
13	IV	„ last cont. (b)	18 38 38.6	M. D.

(a) Unsatisfactory from cloud. (b) The planet's image much diffused. The initials C., M. D., and R., are those of Mr. Criswick, Mr. Dolman, and Mr. Roberts.

*Observations in Australia of the Transit of Mercury of the
12th November, 1861.*

Mr. Scott, in a letter dated Observatory, Sydney, November 22d, 1861, writes:—

“The transit of *Mercury* which occurred on the 12th instant was only partially observed, on account of the cloudy state of the sky. The time of internal contact was $3^h 24^m 34^s$ Sydney mean time. The egress occurred after sunset.”

And he encloses the following notice, received from Mr. Todd, at Adelaide:—

“I make time of total ingress, $2^h 34^m 12^s$.

First contact, egress.....	$6^h 30^m 29^s$
Last contact, egress.....	$6^h 32^m 19^s$

“The first two may be considered good, especially the ingress. The last is uncertain, the Sun being low down and boiling.”

Mr. Ellery, in a letter dated Observatory, Williamstown, Victoria, November 25th, 1861, writes:—

“We observed the ingress and a portion of the transit of *Mercury* across the Sun's disk on the 12th instant.

“It was cloudy most of the day, but the weather cleared up about 1 P.M., leaving us an almost clear sky until some time after the ingress of the planet. The egress took place after sunset to us.

“I observed the first contact, or rather *indentation*, at $2^h 58^m 2^s$. The first glimpse I got of the notch I estimated, by its subsequent motion, to be about 8^s after the first contact had taken place. The internal contact was lost on account of a passing cloud.

“As I possessed no other than a rough position-micrometer, I could make no measures during the transit.”

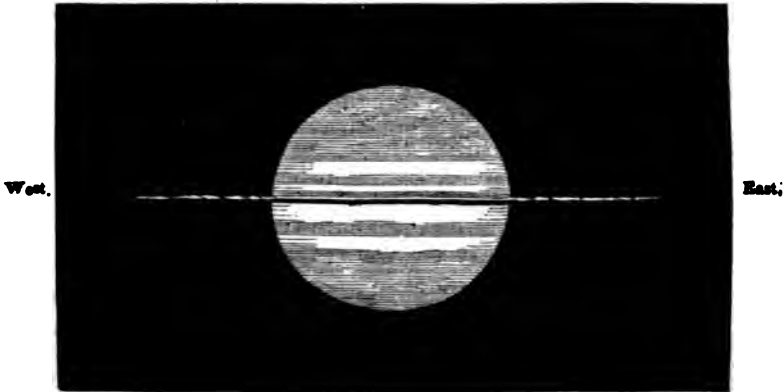
The longitude of the observatory is $9^h 39^m 40^s.01$ E., lat. $37^{\circ} 52' 8''$ S.

Note on Two Drawings of Saturn. By Capt. W. S. Jacob.

Two drawings of *Saturn*, by Captain Jacob, were exhibited at the meeting in December. Captain Jacob writes :—

"No. 1 was taken on the morning of November 12th, shortly before the disappearance of the ring, as seen in Dr. Lee's tele-

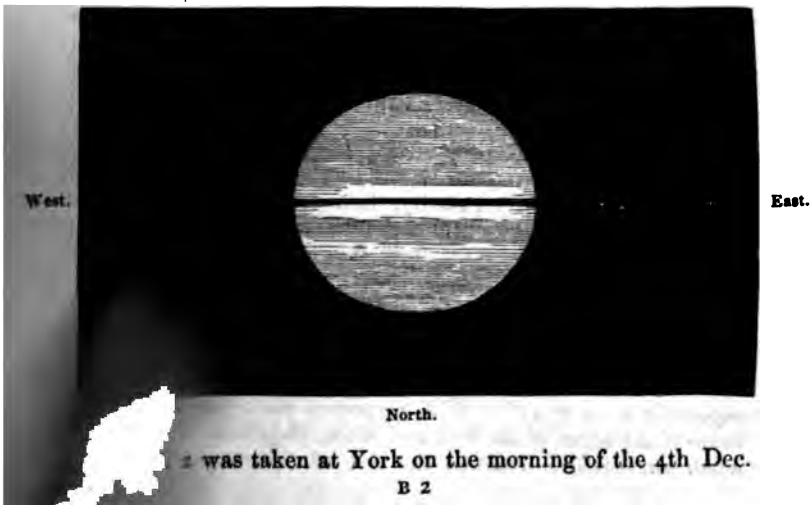
South.



North.

scope at Hartwell. I cannot say how far the inequalities in the ring were due to want of definition. The atmosphere was not in prime condition, and scarcely bore the power of 240 ; yet, when the definition seemed at its best by occasional glimpses, the inequalities were the most conspicuous.

South.



with the 9-inch object-glass, which Messrs. Cooke and Sons have been preparing for my equatoreal. The excellence of its defining power may be judged of from the fact of its separating the dark streak across the planet into two parts, with an almost inconceivably fine line of light between, viz., the ring itself and its shadow. The breadth of the former could not have been much more than $0^{\circ}.04$.

"Only four satellites could be seen, viz., *Titan*, at some distance, and the three shown in the drawing, of which the outermost is *Tethys*, and the other two, probably, *Dione* and *Enceladus*.

"*Hartwell, near Aylesbury,*
December 11, 1861."

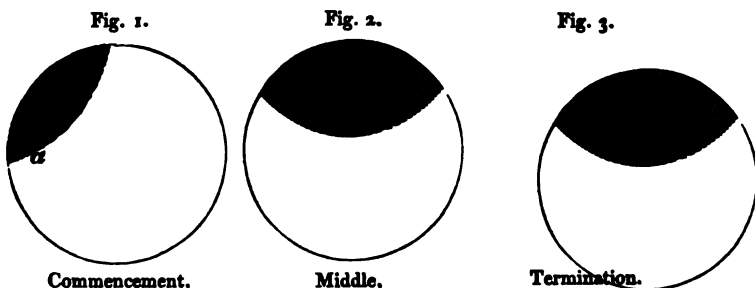
The Solar Eclipse of the 31st December, 1861, observed at Kilkenny House, Sion Hill, Bath. By R. W. H. Hardy, Esq., R.N.

As the clouds cleared off about noon, we were enabled to view the eclipse uninterruptedly. The moment of first contact was not accurately noticed. It appeared to take place at $1^h 45^m$ G.M.T. Soon after the eclipse began, and for some time afterwards, the overlapping surface of the Moon was covered over with a soft grey tint, which terminated on the advancing edge in a narrow band of deep purple. Concurrently with this purple band, there appeared in advance of the Moon's edge, but concentric with it, at a short distance, a bright gleam of light brighter than the solar disk. This light was separated from the Moon's edge by a narrow pale green shadow, which softened into the former. This is also the character of all shadows from objects on our Earth. At 2^h the Moon's edge undulated rapidly, while the Sun's edge remained comparatively tranquil. About this time also, the outline of the Moon appeared to form an irregular curvature, bulging out at the edge a , figure 1. This irregularity, however, diminished as the Moon advanced till she reached the central line, when it ceased; but began again to increase from this epoch till it reached a second maximum near the point a' , figure 3, at 3^h G.M.T. Before this, at $2^h 15^m$, a bright yellow-green light reflected from the Moon's edge and contiguous surface attracted our notice, which not only brought out our satellite in strong relief, but also showed the lunar surface beautifully foreshortened, especially so at $3^h 35^m$. With respect to the apparent undulations of the edges of the Sun and Moon, they were about equal when our satellite reached the line of centres, and at their

greatest difference of velocity when she attained the two opposite points *a* and *a'*, figures 1 and 3. When the moon reached the middle of the eclipse, as shown in figure 2, and by carefully excluding every ray of direct solar light, the Moon's edge was traceable upwards to a considerable distance from both cusps, as if illuminated by a faint twilight. The conclusion of the eclipse was not seen, owing to the thickness of the sky about that time.

My telescope is a 12-inch Newtonian reflector; the eyepiece I used on the occasion was an inverting one, and the power employed 60 times, which takes all the sun into the field. The projecting glass was a neutral tint, which does not materially affect the appearance of the colour of natural objects.

Inverted Images.



Eclipse of the Sun of 31st December, 1861, observed at Nice.

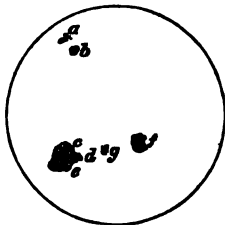
By C. G. Talmage, late of the Greenwich and Regent's Park Observatories, Assistant to T. Coventry, Esq., 5 Tavistock Square.

(Communicated by Mr. Hind.)

The instrument used was a 5-foot Equatoreal, the stand and metal-work being constructed by Troughton and Simms; but the object-glass, which has a clear aperture of 4 inches, is of Munich manufacture.

Every precaution was taken that the first contact should be accurately observed; and the time, thermometer, and barometer observations are put by themselves, as being easier for reference.

At the total immersion of spot (*b*), it seemed suddenly to blaze forth, and quite a mauve tint was visible all round it. I



have only seen one instance on record of such an occurrence (Hind's *Solar System*, p. 65). The Moon's limb presented no irregularities. As the obscuration advanced to its greatest phase, a very sensible difference took place in the temperature of the atmosphere. At about 3^h 25^m M.T. a very cold north-east wind sprung up, and blew for about half an hour—so cold that most of the visitors on the promenade (Promenade des Anglois) returned home, and at the greatest phase only a few gentlemen with coloured glasses were left. At this time, also, *Venus* shone forth with great brilliancy; *Arcturus*, *Antares*, and *Aquila* were looked for without success. At 3^h 45^m, a remarkable phenomenon presented itself on the surface of the Moon: there appeared a semicircular streak of red light close to the limb, gradually diminishing to two abrupt points. About this time the landscape had a very peculiar tinge: the mountains at a great distance appeared of a deep blue tinge, and seemed to stand out with unnatural distinctness. Spot (*e*) was only just grazed by the Moon's limb. The Sun unfortunately setting before the eclipse had ended, we had not an opportunity of observing the time of last contact.

Nice M.T. of first contact.....	^h	^m	^s
	2	27	22.80
Time of first contact of spot (<i>a</i>) ...	2	34	31
„ total immersion	2	34	45
Time of first contact of spot (<i>b</i>) ...	2	35	53
„ total immersion	2	36	36
Time of first contact of spot (<i>f</i>) ...	3	16	30
„ central bisection	3	17	16
„ total immersion	3	18	0
Time of total immersion of spot (<i>g</i>)	3	20	5
Time of first contact of spot (<i>c</i>) ...	3	21	40
„ total immersion	3	24	0

Time of first contact of spot (*d*) ... $3^{\text{h}} 26^{\text{m}} 50^{\text{s}}$
 ,, total immersion $3^{\text{h}} 29^{\text{m}} 30^{\text{s}}$

Time of total emersion of spot (*c*) $3^{\text{h}} 38^{\text{m}} 35^{\text{s}}$

Time.	Barom.	Therm. in Shade.	Therm. in Sun.
0.0	$30^{\circ} 32.7$	$68^{\circ} 8$	$93^{\circ} 1$
0.30	$30^{\circ} 32.7$	$69^{\circ} 8$	$90^{\circ} 0$
1.15	$30^{\circ} 31.5$	$67^{\circ} 7$	$75^{\circ} 5$
2.20	$30^{\circ} 30.5$	$65^{\circ} 7$	$73^{\circ} 3$
2.40	$30^{\circ} 30.0$	$64^{\circ} 5$	$72^{\circ} 5$
3.10	$30^{\circ} 30.0$	$62^{\circ} 2$	$65^{\circ} 0$
3.30	$30^{\circ} 30.0$	$60^{\circ} 3$	$60^{\circ} 8$
3.50	$30^{\circ} 30.0$	$59^{\circ} 0$	$59^{\circ} 0$
4.5	$30^{\circ} 30.0$	$57^{\circ} 8$	$58^{\circ} 8$

P.S. The observations were made at the Grand Hotel Chauvain.

Occultations of Stars by the Moon. Observed by
 C. G. Talmage, Esq.

The observations were made at the Grand Hotel Chauvain, Nice, with a 5-foot equatoreal, aperture 4 inches.

Occultation of *R Aquarii* on Moon's dark limb, January 4, 1862:—

The dark limb was beautifully defined; the star appeared to be bisected by, or hung in, the Moon's limb for 8^s or 10^s.

Nice mean time of disappearance = $7^{\text{h}} 34^{\text{m}} 3^{\text{s}} 00$.

Occultation of *103 Tauri* on Moon's dark limb:—

Star disappeared instantaneously. January 12, 1862.

Nice mean time of disappearance = $9^{\text{h}} 23^{\text{m}} 40^{\text{s}} 60$.

Occultation of *1 Geminorum* on Moon's dark limb:—

Star very faint as it neared the Moon's limb. 1862, January 13.

Nice mean time of disappearance = $12^{\text{h}} 32^{\text{m}} 1^{\text{s}} 00$.

Additions and Corrections to the Observations of Comet II.,
1861. By the Rev. R. Main, Radcliffe Observer.

By inadvertence the observations of 1861, August 29, were omitted; they are as follows:—

	Greenwich M.T.	Apparent R.A.	Apparent N.P.D.
	^h ^m ^s	^h ^m ^s	[°] ['] ["]
Aug. 29	8 32 31 [·] 3	15 30 57 [·] 77	46 12 12 [·] 6
	8 47 28 [·] 0	15 31 0 [·] 90	46 12 11 [·] 6
	9 10 4 [·] 4	15 31 1 [·] 17	46 12 33 [·] 4

The following corrections are to be made:—

Page 51, July 5. The N.P.D.'s opposite the 2d and 3d observations of this day belong to the 3d and 4th observations.

Page 52, Aug. 6, 3d observation, the Greenwich mean time should be 11^h 38^m 20^s·0, instead of 11^h 38^m 2^s·0.

Page 54, July 14, 15, 16. The places of the two anonymous stars set down are only approximate, and have not been employed in the reductions.

Page 54, Aug. 19. *For* Radcliffe 3387, *read* Radcliffe 3385.

Radcliffe Observatory, Oxford,
1862, Jan. 20.

Observations and Elements of Comet III., 1861. Communicated by G. P. Bond, Director of the Observatory of Harvard College, Cambridge, U.S.

A telescopic comet was discovered at this observatory by Mr. H. P. Tuttle, at 3 A.M. Dec. 29th. The following observations and elements have been obtained:—

Observations of Comet.

[By a provisional reduction.]

	Cambridge M.T.	R. A.	Decl.
	^h ^m ^s	^h ^m ^s	[°] ['] ["]
1861, Dec. 28	18 25 34	14 12 55 [·] 3	−5 12 39
„ „ 30	18 20 16	14 15 29 [·] 9	−1 24 42
1862, Jan. 1	18 37 18	14 18 39 [·] 0	+3 9 31

Mr. Bond, Observations and Elements of Comet III. 95

The following elements have been computed by T. H. Safford, Assistant at the Observatory:—

1861, Washington M.T. Dec 6·9867.

$\log q = 9·92400.$

$\omega^* = 331^{\circ} 39' 10''$

$\Omega = 145^{\circ} 8' 78''$, App. Eq., Jan. 1, 1862.

$i = 41^{\circ} 58' 40''$

Motion retrograde.

* Distance of the perihelion from the ascending node in the direction of motion.

The middle observation is represented as follows:—

C — O.

$\delta \lambda \cos \beta + 0' 19''$

$\delta \beta + 0' 03''$

The subjoined Ephemeris may, perhaps, be useful for the reduction of observations:—

18 ^h Washington.	Comet's R. A.	Comet's Decl.	Log. Δ.
1862, Jan. 1	214 40 ⁰	+ 3 8 ⁰	9·775
3	215 37	8 36	9·714
5	216 49	15 9	9·675
7	218 19	22 59	9·638
9	220 18	32 3	9·609

About the 20th instant it will approach the north pole.

Observatory of Harvard College,
Jan. 3d, 1862.

The same Comet was observed at Pulkova:—

8th Jan. 1862 14^h 21' M. T. R. A. 218^h 49^m Decl. 25° 22' N.

And at Altona:—

	M. T.	R. A.	Decl.
	h m s	h m s	° ' N.
18th Jan.	7 28 0	16 29 35	73 21 N.
19th „	6 23 45	17 9 37	76 42 N.

Minor Planet (50).

The name *Olympia* has been given to this planet.

ERRATA.

- P. 38 (Mr. Lassell's Observations of the Transit of *Mercury*), for "Piazzi Stierna," read "Piazzi Slierna."
 P. 40 (Prof. Chevallier's Account of the same Transit), immediately before Mr. Marth's Observations, *insert*, "But these observations, and especially those in declination, are regarded as sufficiently accurate only to show that the tables are nearly correct, the trembling of the Sun's limb rendering them uncertain."

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MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. XXII. February 14, 1862. No. 4.

THE Annual General Meeting of the Society, Dr. LEE, President, in the Chair.

Arthur Cottam, Esq., 1 Whitehall Place ;
 Wm. Thynne Lynn, Esq., Superintendent of Computers,
 Royal Observatory, Greenwich ;
 The Hon. Samuel Cockburne, Governor of Montserrat,
 West Indies ;
 George Dollond, Jun., Esq., 59 St. Paul's Churchyard ; and
 Charles Mason, Esq., 16 Queen's Road, Regent's Park,
 were balloted for and duly elected Fellows of the Society.

After the business was concluded, a Special General Meeting was held for the purpose of electing Miss Sheepshanks an Honorary Member of the Society, which was done accordingly.

Report of the Council to the Forty-second Annual General Meeting of the Society.

The Report of the Auditors, subjoined, will show the state of the finances :—

RECEIPTS.

	£	s.	d.
Balance of last year's account	276	19	3
By dividend on £2000 Consols	28	15	0
By ditto on £3500 new 3 per Cents	50	6	3
By ditto on £2100 Consols	30	6	5
Carried forward.....	£386	6	11

	£	s.	d.
Brought forward	386	6	11
By dividend on £5800 New 3 per Cents	54	17	3
On account of arrears of contributions	81	12	0
115 contributions (1861-62)	241	10	0
1 contribution (balance for 1862)	1	1	0
7 compositions	147	0	0
35 admission-fees	73	10	0
30 first year's contributions	57	15	0
3 contributions for 1863	6	6	0
Sale of Publications	70	2	0
By cash for India Hill Observatory	1000	0	0
	<u>£2120</u>	<u>0</u>	<u>2</u>

EXPENDITURE.

Salaries:—	£	s.	d.	£	s.	d.
Mr. Cayley, 1 year as Editor of the Society's Publications	60	0	0			
Mr. Williams, 1 year as Assistant-Secretary	100	0	0			
Ditto commission on collecting £531 16s.	26	0	0	186	0	0
Investments:—						
Investing £100 Consols				91	10	0
Taxes:—						
Property Tax, 1 year	4	7	6			
Assessed and Land, ditto	2	1	8	6	9	2
Bills:—						
Strangeways and Co., printers	415	15	0			
J. Basire, engraver	42	0	0			
Joyce, engraver	1	10	0			
C. Frodsham, clock ..	3	7	6			
Insurance (Sun Fire Office)	12	5	6			
L. Wyon, medals	57	15	0	532	13	0
Miscellaneous items:—						
Charges on books, and carriage of parcels ...	4	15	8			
Postage of <i>Monthly Notices</i> , letters, &c.	39	15	4			
Porter's and charwoman's work	24	13	6			
Tea, sugar, biscuits, &c. for evening meetings	13	13	0			
Waiters attending meetings	3	17	0			
Coals, &c.	12	0	0			
Sundry disbursements by the Treasurer	28	3	1			
Sundry payments out of Turnor Fund	0	13	6			
Deductions on country cheques	0	1	2			
Mrs. Jackson's annuity, half-year	4	6	8	131	18	11
India Hill Observatory, <i>contra</i>				1000	0	0
Balance at Banker's				171	9	1
				<u>£2120</u>	<u>0</u>	<u>2</u>

Assets and present property of the Society, Feb. 8, 1862:—

		£	s.	d.
Balance at Banker's		171	9	1
1 contribution of 4 years' standing	8 8 0			
8 ——— of 3 ditto	50 8 0			
13 ——— of 2 ditto	54 12 0			
33 ——— of 1 ditto	69 6 0			
		182	14	0
Due for publications of the Society		2	2	0

£3800 new 3 per Cents. (including Mrs. Jackson's gift).

£2100 Consols (including the Lee Fund).

Unsold publications of the Society.

Various astronomical instruments, books, prints, &c.

Balance of Turnor Fund (included in Treasurer's account) ... 59 19 10

Stock of volumes of the *Memoirs*:—

Vol.	Total.	Vol.	Total.	Vol.	Total.
I. Part 1	26	IX.	188	XXI. Part 1 (separate).	204
I. Part 2	68	X.	200	XXI. Part 2 (separate).	100
II. Part 1	85	XI.	210	XXI. (together).	117
II. Part 2	50	XII.	217	XXII.	211
III. Part 1	106	XIII.	234	XXIII.	212
III. Part 2	125	XIV.	218	XXIV.	222
IV. Part 1	121	XV.	202	XXV.	227
IV. Part 2	134	XVI.	223	XXVI.	239
V.	154	XVII.	201	XXVII.	494
VI.	174	XVIII.	206	XXVIII.	456
VII.	197	XIX.	214	XXIX.	281
VIII.	183	XX.	211		

Progress and present state of the Society:—

	Compounders.	Annual Contributors.	Non-residents.	Patroness, and Honorary.	Total Fellows.	Associates.	Grand Total.
February 1861 ...	161	207	31	4	403	51	454
Since elected	5	30	...	...	...	...	...
Deceased	—4	—3	...	...	...	—2	...
Removal	2	—2	...	...	...	...	...
February 1862 ...	164	232	31	4	431	49	480

The instruments belonging to the Society are as follows:—

The *Harrison* clock,
 The *Owen* portable circle,
 The *Beaufoy* circle,
 The *Beaufoy* transit,
 The *Herschelian* 7-foot telescope,
 The *Greig* universal instrument,
 The *Smeaton* equatoreal,
 The *Cavendish* apparatus,
 The 7-foot Gregorian telescope (late Mr. Shearman's),
 The Variation transit (late Mr. Shearman's),
 The Universal quadrant by Abraham Sharp,
 The *Fuller* theodolite,
 The Standard scale,
 The *Beaufoy* clock,
 The *Wollaston* telescope,
 The *Lee* circle.

The *Sheepshanks'* collection of instruments, viz.,—

1. 30-inch transit, by Simms, with level and two iron stands.
2. 6-inch transit theodolite, with circles divided on silver; reading microscopes, both for altitude and azimuth; cross and siding levels; magnetic needle; plumbline; portable clamping foot and tripod stand.
3. $4\frac{1}{8}$ -inch achromatic telescope, about 5 feet 6 inches focal length; finder, rack motion; double-image micrometer; object-glass micrometer; two other micrometers; one terrestrial and ten astronomical eyepieces, applied by means of two adapters.
4. $3\frac{1}{4}$ -inch achromatic telescope, with equatoreal stand; double-image micrometer; one terrestrial and three astronomical eyepieces.
5. $2\frac{1}{2}$ -inch achromatic telescope, with stand; one terrestrial and three astronomical eyepieces.
6. $2\frac{1}{2}$ -inch achromatic telescope, about 30 inches focus; one terrestrial and four astronomical eyepieces.
7. 2-foot navy telescope.
8. 45-inch transit instrument, with iron stand, and also Y's for fixing to stone piers; two axis levels.
9. Repeating theodolite, by Ertel, with folding tripod stand.
10. 8-inch pillar-sextant, divided on platinum, with counterpoise stand and horizon roof.
11. Portable zenith instrument, with detached micrometer and eyepiece.
12. 18-inch Borda's repeating circle, by Troughton.
13. 8-inch vertical repeating circle, with diagonal telescope, by Troughton and Simms.

14. A set of surveying instruments, consisting of a 12-inch theodolite for horizontal angles only, with extra pair of parallel plates; tripod staff; in which the telescope tube is packed; repeating table; level collimator, with micrometer eyepiece; and Troughton's levelling staff.
15. Level collimator, plain diaphragm.
16. 10-inch reflecting circle, by Troughton, with counterpoise stand; artificial horizon, with metallic roof; two tripod stands, one with table for artificial horizon.
17. Hassler's reflecting circle, by Troughton, with counterpoise stand.
18. 6-inch reflecting circle, by Troughton, with two counterpoise stands, one with artificial horizon.
19. 5-inch reflecting circle, by Lenoir.
20. Reflecting circle, by Jecker, of Paris.
21. Box sextant and 3-inch plane artificial horizon.
22. Prismatic compass.
23. Mountain barometer.
24. Prismatic compass.
25. 5-inch compass.
26. Dipping needle.
27. Intensity needle.
28. Ditto ditto.
29. Box of magnetic apparatus.
30. Hassler's reflecting circle, with artificial horizon roof.
31. Box sextant and $2\frac{1}{2}$ -inch glass plane artificial horizon.
32. Plane speculum artificial horizon and stand.
33. $2\frac{1}{2}$ -inch circular level horizon, by Dollond.
34. Artificial horizon roof and trough.
35. Set of drawing instruments, consisting of 6-inch circular protractor; common ditto; 2-foot plotting scale; two beam compasses and small T square.
36. A pentagraph.
37. A noddy.
38. A small Galilean telescope, with the object lens of rock-crystal.
39. Six levels, various.
40. 18-inch celestial globe.
41. Varley stand for telescope.
42. Thermometer.
43. Telescope.

These are now in the apartments of the Society, with the exception of the following, which are lent, during the pleasure of the Council, to the several parties under mentioned, viz.:—

The *Wollaston* telescope, to Mr. Rees.
 The *Lee* circle, to Mr. Burr.
 The *Beaufoy* clock, to Dr. Booth.

The <i>Sheepshanks</i> instrument,		No. 1, to Mr. Lassell.
Ditto	ditto	No. 2, to Mr. De La Rue.
Ditto	ditto	No. 3, to Rev. C. Pritchard.
Ditto	ditto	No. 4, to Rev. F. Howlett.
Ditto	ditto	No. 5, to Mr. Birt.
Ditto	ditto	No. 6, to Rev. J. Cape.
Ditto	ditto	No. 8, to Prof. Wheatstone.
Ditto	ditto	No. 10, to Rev. C. Pritchard.
Ditto	ditto	No. 19, to Mr. Dayman.
Ditto	ditto	No. 23, to Mr. Spottiswoode.
Ditto	ditto	No. 25, to Mr. Dayman.
Ditto	ditto	No. 41, to Rev. C. Pritchard.
The double-image micrometer,		to Mr. Hodgson.
The 6-inch circular protractor,		to Mr. Birt.

Nothing definite has yet been ascertained respecting the other *Beaufoy* clock, the two invariable pendulums, and the quadrant (said to have been *Lacaille's*), reported for many years past as being in the possession of the Royal Society.

The Fellows are aware that the Council intend this day to propose, at a Special General Meeting, that the name of Miss Anne Sheepshanks be added to the list of Honorary Members. The splendid present of instruments made by this lady to the Society, and the large endowment by which she has perpetuated the name of her brother and his astronomical pursuits in his own university, most properly call for such acknowledgment as a Society devoted to Astronomy can give. So much might be said in any similar case. But when it is remembered that the brother whose memory is thus affectionately preserved was one of the best friends this Society ever had, equalled only by Francis Baily in the amount of time and labour which he bestowed upon it, and the untiring zeal with which he served it, the Council feel, and are sure the Society at large will also feel, that the duty of acknowledgment will be performed with greater pleasure in that it again connects us with the name of Sheepshanks.

The Council have to announce the receipt of a handsome reversionary gift. Mrs. Hannah Jackson has made over 300*l.* stock, reserving the dividends during her life, for the promotion of Astronomy by rewards to be given in the name of "Hannah Jackson, *née* Gwilt." The conditions, including some slight modifications to which Mrs. Jackson at once consented on the suggestion of the Council, are as follows. When the endowment takes effect, the accumulations of income, for any term not exceeding seven years, are, at the discretion of the Council, to be from time to time given in the form of a medal, or of money, or both, to the writer of any astronomical work or memoir, the inventor or improver of any astronomical

instrument, the discoverer of any new heavenly body, or the promoter in any other way of the science of Astronomy. The Council invite the Fellows to return thanks to Mrs. Jackson, not only for this very munificent gift, but for the judgment shown in allowing the mode of employment to be unfettered by any restrictions which might possibly diminish its utility.

The Council have awarded the Gold Medal to Mr. Warren De La Rue, for his astronomical researches, and especially for his application of Photography. The President will, in the usual way, explain the grounds of this award in detail: but the Council cannot help remarking that this public recognition of the success of chemical delineation of celestial objects may be an important date in the history of Astronomy. No discovery of our day affords a more hopeful field of anticipation than that of photography, which seems destined to take that part in the astronomy of visual phenomena which graduated instruments have taken in the astronomy of motions and positions.

The volume of *Memoirs* will shortly appear. It contains two papers only, these are, first, a Memoir On the Lunar Theory, by Sir J. W. Lubbock, Bart., of which an abstract was published in the *Monthly Notices*, January 1861. The memoir relates chiefly to the comparison and discussion of the numerical values of the coefficients of the several inequalities as given by M. Plana and M. de Pontécoulant, and in the American Tables, Washington, 1853; but it contains also theoretical investigations in relation to the acceleration and to certain long inequalities. Secondly, Observations on Donati's Comet—Sketches and Notes by Messrs. Lassell, Dawes, and Webb, Prof. Challis, the Astronomer Royal, and Mr. De La Rue. The paper is drawn up by Mr. Carrington. It is illustrated by eight plates.

Pursuant to the Report of a Committee on Income and Expenditure, it has been arranged that the ballot for printing of the papers intended for the *Memoirs* is to be deferred until the Council Meeting in June in each year, when a scheme of the whole volume for the year is to be submitted to the Council. The final decision upon papers provisionally approved of for the *Memoirs* is by this regulation deferred until the June Meeting.

The Council have thought it in the interest of the Society to prepare an Index of the *Memoirs*, and to offer sets for sale at a considerably reduced price. The scarcity of parts of the two first volumes has necessitated a considerable difference in the price of complete sets, and sets wanting vols. 1 and 2. The sales have not been very numerous at present, but (in whatever number effected), they tend to diminish the dead

stock, to disseminate the writings and conclusions of astronomers, and thereby directly to promote the objects of the Society, assist its funds, and increase the number of those interested in the subject.

It will hardly be necessary to inform the Meeting that the Council thought it their duty to present an Address of heartfelt condolence to Her Majesty, the Patroness of the Society, on the lamented death of the Prince Consort. Our history has never offered an occasion of the kind in which such addresses have been so thoroughly real and genuine. The country has felt for the Queen as if she had been a member of every family in the kingdom; and every useful institution mourns the loss of a real friend in the good and able Prince Albert.

The Society has to regret the loss by death of George Bishop, Esq.; Sir W. Cubitt; T. F. Ellis, Esq.; Dr. Fitton; T. Forster, Esq.; Sir W. K. Murray; General Sir Charles Pasley; W. Wilson, Esq.; M. Daussy; and M. Biot.

GEORGE BISHOP was born at Leicester, August 21, 1785. From the age of eighteen he lived in London, employed in the well-known business to which he eventually succeeded. By this he added to his patrimony and became very wealthy, as do many others who well deserve the praise of serving their country in the way which they choose of serving themselves. But Mr. Bishop had also a strong love of science, and an earnest but very quiet desire of making his tastes useful, and investing some of his money in a way which would produce a higher return than can be measured by per-centage. Astronomy was a particular object of interest to him, and to obtain knowledge of it he cultivated mathematics to a greater extent than would have been supposed likely. When nearly fifty years of age, at the time when the firm establishment of his business made him feel a right to relaxation, he made a very serious study of mathematics, and mastered enough of the *Mécanique Céleste* to obtain a perfect idea of the nature of the great problems of astronomy. His conversation never gave any idea of his knowledge in this and other matters: he listened more than he talked, and was not communicative about himself or his plans.

He had always had a great wish to possess an Observatory, but never had the opportunity until he removed his residence to South Villa, in the Regent's Park. The Observatory was erected in 1836. Mr. Bishop was from the beginning well aware that by far the most important part of an astronomical instrument is the astronomer. This is the foundation of the true theory of an instrument; and the Chaldean shepherd, with no lens except that of the eye, added more to

the knowledge of the heavens than all the unused telescopes put together. Mr. Bishop, knowing that his own leisure would never suffice to work an observatory, determined that what he could not do others should. From the beginning this was his firm resolution. It was often expressed to the writer of this memoir, who especially remembers one occasion, when both were standing on the spot now occupied by the Observatory, after walking over the grounds to look for a site. "I am determined," said Mr. Bishop, "that this Observatory shall *do something*." The known solar system at that time consisted of eleven planets. Little did either party to the conversation think that the duplication of this number was part of the reward in store for Mr. Bishop's energetic and single-minded resolution to be of use.

Every particular relating to the Observatory will be found in Mr. Bishop's publication, *Astronomical Observations during the years 1839-51*. It is not necessary for us here to describe Mr. Hind's ten planets, that of Mr. Marth, the star in *Ophiuchus*, the variable stars, the new nebulae, the valuable double-star observations commenced by Mr. Dawes, &c. The eclipitic charts must be mentioned: seventeen are engraved, and it is hoped that the difficulties in the way of the completion are now overcome.

The South Villa Observatory is connected with a succession of excellent astronomers. We need only mention the names of Mr. Dawes and Mr. Hind. Since his appointment to the *Nautical Almanac*, Mr. Hind has taken a general superintendence, the actual observers being in succession Mr. Norman Pogson, Dr. Vogel, Mr. Marth, and Mr. Talmage. Mr. Pogson commenced in this Observatory the career which has produced much and promises more: and this was always a source of high gratification to Mr. Bishop.

Mr. Bishop was elected Fellow of this Society in 1830. He was successively Secretary, Treasurer, and President. It will always be matter of regret that he was never once able to take the chair in the last capacity: the final prostration of strength which accompanied—we may almost say, constituted—his last illness, was nearly simultaneous with his election as President in February 1857. He continued in a state of fluctuating debility, without any loss of mind, until June 14, 1861, when he died without pain.

We cannot here undertake to dwell at length upon the characteristics of this good friend of our Society, and most active, though quiet, promoter of its cause. Those who were on terms of intimacy with him will never forget the excellencies of his private character. Our concern is with the manner in which he encouraged and promoted Astronomy. In 1848, speaking on the award of our Astronomical testimonials, Sir J. Herschel observed that "it does not fall to the lot of every private observatory to have added two planets to our

list." This was said at a time when the career of discovery of small planets was in its infancy. We may note that on the first opening of this path the energies of the South Villa Observatory were turned at once upon it; and the success which followed was a very great stimulus to the exertions of others. We have much satisfaction in adding that this institution is not to become extinct. It is the intention of Mr. George Bishop the younger to remove the instruments and the dome to his residence at Twickenham, and to continue the course of observation so brilliantly commenced in the Regent's Park.

Sir WILLIAM CUBITT was born at Dilham, in Norfolk, in 1785. As an engineer, his career will be recorded in other publications. He became a member of our Society, as other engineers have done, attracted towards astronomy by its connexion with mechanical adaptation. He was a good transit observer, and he constructed Mr. Cooper's telescope tube. The inventor of the self-acting windmill-sail, the constructor of the great landing-stage at Liverpool, the executive engineer of the railway from London to Dover, the superintendent of the construction of the Crystal Palace of 1851, is not likely to be forgotten in his line. The host of minor undertakings which he directed is past all enumeration; and it must not be forgotten that he deserves the thanks of every honest man as the inventor of the treadmill.

Sir William Cubitt was the son of a miller, and became a millwright after being apprenticed to a joiner. He has, accordingly, been represented as having risen in the face of every disadvantage; but this was not the fact, though easily credible of such a man. The apprenticeship was probably considered as an additional introduction to his intended career, he having already had much experience of the special working of a mill in his father's business.

Mr. Bidder states that his success was in a great degree to be ascribed to the soundness of his early mechanical experience, which he never failed to impress upon all the younger members of his profession. He died in October last.

THOMAS FLOWER ELLIS was born December 5, 1796, and died April 5, 1861. He was educated at Cambridge, where his career in classics was distinguished, and he gained a fellowship at Trinity College in 1819, which he vacated by marriage in 1820. He was called to the bar in 1824, and continued in practice till his death, being for many years one of the reporters of the Court of Queen's Bench. In 1839 he was made Recorder of Leeds, and Attorney-General for the Duchy of Lancaster. He was one of our earliest members, having been elected in May, 1820. He was elected to the Royal Society in 1847, and was also a member of the Cam-

bridge Philosophical Society, the Philological Society, &c. On the Northern Circuit he made the acquaintance of the late Lord Macaulay, with whom he contracted a warm friendship. Lord Macaulay made him his executor, and in this capacity he edited the posthumous works of his distinguished friend.

Mr. Ellis was one of a class which is more numerous in England than in any other country—the class of persons who carry into professional life what would on the Continent be a *professorial* knowledge of literature or science, and make it the duty of their leisure to apply it to the benefit of others. He was for many years a hardworking member of the Society for the Diffusion of Useful Knowledge, which he took up from the commencement with the feeling of personal responsibility for what was published by that corporation. In various other ways he was steadily applying himself to utilities of the same kind. In his career at the bar he also occupied a post of importance, to which no public recognition is attached. The reporters of our courts of law, on whom the judges mainly depend, not only for precedents, but for the arguments on which they are founded, are themselves unknown to the courts whose proceedings they record, and belong rather to the publishers who undertake the volumes of reports than to the great system which lives and grows by their publications. But we believe we may say that the judges themselves are not more free from all impeachment than their reporters.

Mr. Ellis was attached both to literature and to science, but his tastes were of a very mathematical cast. His principle, throughout life, was the promotion of knowledge; and in this field he worked from the time when he joined our Society in its infancy to the end of his useful life. None but those who were either his friends or colleagues were cognisant of his career.

The Council regret that his pursuits of necessity severed him from active participation in our meetings of the Society; and they feel that they have lost a member whose course of life was a continual credit to every Society whose designation he attached to his name, and to ours from its very commencement.

The Council regret that they cannot procure an account of Dr. FITTON. This zealous geologist had been a Fellow of the Society since 1825, and, though not immediately connected with astronomy, often attended our meetings. Almost to the last he was seen among us on occasions when important subjects were agitated.

THOMAS IGNATIUS MARIA FORSTER was born in Threadneedle Street, November 9, 1789. He was of an ancient Border family, which was confiscated in the Rebellion of 1715.

His father, who was in business, was a zealous botanist, and published a *Flora Tunbrigiensis* in 1812. His uncle, B. Meggot Forster, was known by many papers on physics and botany; and another uncle, Edward, a partner in the house of Lubbock and Co., was also known as a botanist. Thomas Forster has left an account of his own life, published in French at Brussels in 1836: he speaks in detail of the botanical tendency of his family, and says that as soon as the ledger was shut the *hortus siccus* was open. He himself began, at the age of sixteen, a *Liber Rerum Naturalium*, and a *Journal of the Weather*, which he continued till his death.

At the age of seventeen he became acquainted with Spurzheim, whose system he adopted. It was Mr. Forster who gave the name of *Phrenology* to what was till then called *Craniology*, in a tract entitled *Sketch of the Phrenology of Gall and Spurzheim*, London, 8vo, 1816. Spurzheim told him that he had a head well organised for science, but with too much *ideality* to allow it to be used with effect.

Mr. Forster was a member of Corpus Christi College, Cambridge, and took the degree of M. B. in 1819. In 1817 he married a daughter of Colonel Beaufoy, a well-known Fellow of this Society, which he himself joined in 1824. He led a wandering life till about 1834, when he settled in Belgium, where he remained till his death, either at Brussels or at Bruges. He spoke and wrote various languages with facility. His detached works are beyond all enumeration: most of them are on atmospherical and meteorological phenomena, not forgetting an account of a balloon-ascent which he made in 1831. One of his earliest works, *On the Brumal Retreat of the Swallows*, published under the name of Philocheledon, reached a sixth edition in 1817.

When M. Quetelet showed him some accounts of the shooting stars of August 10, he was greatly astonished; but a few days afterwards he pointed out to M. Quetelet that he had long before announced the phenomenon as periodic, in his own Atmospherical Calendar, which he had entirely forgotten. This was made known at the time.

Mr. Forster was an upright and amiable man, with many peculiarities of mind and habit; a scholar and a linguist of very wide reading, and zealously attached to observation of natural phenomena.

Sir WILLIAM KEITH MURRAY, Bart., was born at Ochtertyre, in Perthshire, on the 19th of July, 1801. Educated at Harrow and Sandhurst, he entered the army in 1821, joining the 42d Highlanders, where he attained the rank of captain. In 1830 he left that celebrated corps, and joined the Perthshire Militia as lieutenant-colonel. More recently still, on the rise of the Volunteer movement, he was appointed colonel of the

Perthshire Rifle Volunteers, and engaged both enthusiastically and laboriously in those new duties until within a few weeks of his death.

At Sandhurst he had been distinguished for proficiency in military sketching and outline drawing—a talent which he employed abundantly and to good purpose in after-life—publishing, in 1832, a volume of his original sketches of Scottish and Highland scenery, taken in that manner.

He was also an accomplished musician, and was most skilful at the turning-lathe. His taste for telescopic observing only manifested itself later in life; but having, in 1850, erected at Stonehaven a small equatoreal-room of 15 feet in diameter, on the plan described by Sir John Herschel in his work on the *Southern Heavens as observed at the Cape of Good Hope*, he commenced a larger Observatory in 1853, at his family seat of Ochertyre, and published a description of it, with plates, in 1859.

The most noteworthy particular of the building was, perhaps, the mounting of the great dome, 18 feet in diameter, on the rims of large (2-foot) wheels, the axes of which rested on *fixed* bearings in the wall; proving that this was both an economical and effective practical method of securing an easily revolving roof. Of the instruments, the chief one was an equatorially-mounted telescope, of 9 inches aperture, by Cooke and Sons, of York. The optical qualities of this object-glass he was most unwearied in testing on every known difficult object in the heavens, month after month, and year after year, until he had put beyond all doubt the quality of Mr. Cooke's optical work.

With all this energy and determination of purpose, Sir William preserved remarkable modesty amongst learned men, and ever showed the most kind attention to the wishes of his neighbours and the educational interests of his tenantry and the inhabitants of the neighbouring towns and villages. Hence his own advance in science was much impeded by the time he devoted to others; and an interesting specialty of his Observatory always was, the large number of very respectable telescopes which he had fitted up for the use of all who chose to profit by them. His popular lectures in the neighbourhood were frequent and well attended, illustrated generally with great skill by his own mechanical or optical contrivances. He was, in short, never weary of well-doing according to his position in life, and was one of those men occasionally met with in the world who are gifted with almost superhuman activity, seldom requiring more than three or four hours' sleep, and busily engaged in working or superintending the work of others through the remainder of the day.

Sir William was twice married—first, in 1833, to the only daughter of Sir Alexander Keith, of Ravelstone and Dunottar, in whose right he assumed the name of Keith; and secondly,

on the death of this lady, after having had by her eight sons and three daughters, to Lady Adelaide Hastings, youngest daughter of the first Marquis of Hastings. Lady Adelaide died in December, 1859; and Sir William Keith Murray, who never fully recovered from the effect of her loss, was carried off by an attack of typhus fever in October 1861.

General Sir CHARLES WILLIAM PASLEY, K.C.B. and D.C.L., died at his house at Norfolk Crescent, Hyde Park, on the 19th of last April, in his eighty-first year, having been a member of this Society during twenty-seven years. He was also a Fellow of the Royal, the Geological, the Geographical, and the Statistical Societies, being everywhere active in the cause of practical science.

This distinguished officer was born at Eskdale-Muir, Dumfries, on the 8th of September, 1780, and received the rudiments of his education in the High School at Edinburgh. He was appointed a second lieutenant in the Royal Artillery in his seventeenth year, from whence he was transferred to the Royal Engineers, where he became a captain in 1807, a lieutenant-colonel in 1814, and a colonel in 1831. He was promoted to the rank of major-general in 1840, lieutenant-general in 1851, and general in 1860.

The early years of Pasley's career in the army were marked with activity and incident. In 1799 he was stationed in Minorca, where he remained three years, and was then sent to Malta, in which island he rendered himself very serviceable, inasmuch that General Villettes selected him to go with a confidential communication to Admiral Lord Nelson: and here his professional talent was evinced in a scheme for protecting the exposed heights of Corradino by means of four strongly fortified trapezium redoubts, the plan of which is still preserved among the muniments of that island. He served at the defence of Gaeta in 1806, under the Prince of Hesse Philipstadt; at the battle of Maida with Sir John Stuart; and at the siege of Copenhagen, under Lord Cathcart, in 1807. In the following year he was sent to the Peninsula, where he was in several sharp skirmishes, as extra aide-de-camp to Sir David Baird; and at the battle of Corunna he acted in the same capacity to the commander-in-chief, Sir John Moore. Captain Pasley next served in Walcheren, where, on the 9th of August, 1809, he received a bayonet-wound through the thigh, and a musket-shot which injured the spine, in leading a storming party to a French advanced work on the dyke in front of the citadel of Flushing.

In these incessant services it was the good fortune of Captain Pasley to win the approbation of all the generals under whom he was placed, and by all of whom he was employed on special duties and trusty missions. But his personal activity for the field having been restricted in con-

sequence of the severe wounds which he had received, Lord Mulgrave appointed him Director of the Royal Engineer Establishment for Field Instruction at Chatham, which important post he ably held from the year 1812 till the end of 1841. Nor in this Society should it be forgotten that he there founded an efficient Observatory for initiating young officers into practical astronomy, and which was also supplied with such portable instruments as a military engineer ought to be acquainted with. Shortly after quitting Chatham, he was nominated an Inspector of Railroads.

Meanwhile Colonel Pasley had directed his energetic mind to the removal of wrecks under water by means of voltaic explosions of gunpowder; and in 1838 he blew to pieces the sunken hulls of two merchantmen in Gravesend Reach, so that their fragments were easily weighed. So fortunate an operation led to the gigantic enterprise of clearing the road of Spithead from that well-known incumbrance, the Royal George, a first-rate man-of-war, which had been lying at the bottom more than half a century. This arduous undertaking was most successfully executed; and by the public sale of the guns, copper, timber, and *débris* which were fished up, this very important anchorage was cleared without any expense to the country.

We must mention, in conclusion, that Sir Charles Pasley was an author of considerable note. In 1810, a time of great alarm, he published a very remarkable volume on the *Military Policy of Great Britain*. It was much read, and is a valuable book, whether considered as to its enlarged political views, its fair and candid reasonings, or its spirited patriotism—a meed which is granted even by those who cannot concur in all its doctrines. He also wrote *A Course of Elementary Fortification*, in 2 vols.; *Practical Geometry and Plan-Drawing*; *Improvement of English Weights and Measures*; and *Rules for undertaking the Operations of a Siege*.

For more than half his life Sir C. Pasley strongly advocated the introduction of decimal coins, weights, and measures—never holding with those who would introduce the French units into this country, but desiring the complete introduction of the decimal principle of division. Of this proposal he was one of the earliest supporters.

WILLIAM WILSON was born in Spitalfields in the year 1768. His career affords a striking example of the effect of self-culture in overcoming the disadvantages of a very limited education and want of position. When a mere child, he was employed by a weaver as what was then called a draw-boy. He was afterwards apprenticed to a chair-maker, and followed that calling for a time; but having a strong natural bias towards scientific pursuits, he devoted his leisure to the acquirement of that kind of knowledge, and by industry and

perseverance succeeded in raising himself far above his original position.

In 1796 he joined the Mathematical Society of Spitalfields, a Society which was established in 1717 for the purpose of mutual instruction in the mathematics and the promotion of general science. Here he soon distinguished himself, for the Society having, in 1795, removed to convenient premises in Crispin Street, it was shortly after proposed that a course of elementary lectures on the various branches of natural and experimental philosophy should be annually delivered, to which the public should be admitted at moderate cost. Mr. Wilson, in co-operation with Mr. Joseph Stevens, the Engineer to the East London Waterworks, rendered most effective assistance in carrying out this scheme. The first of these courses was delivered in 1798, and they were continued for nearly thirty years, Mr. Wilson taking an active part in their delivery during the whole of that time.

He was for many years Assistant to Mr. William Allen, Lecturer on Chemistry at Guy's Hospital. When, in 1825, his services were no longer required by that gentleman, having but slender means of support, the Committee of the Mathematical Society, in consideration of the eminent services rendered by him to the Society for so many years, gave him the entire benefit of the course of lectures for that season. Mr. Wilson, consequently, delivered the whole course, being a series extending over about twenty consecutive weeks; the writer of this notice officiating as his Assistant.

He was afterwards employed as Superintendent of the workmen of the Gasworks at Haggerstone; and when, after many years' services, the infirmities of age compelled him to retire from active business, a competent annuity from that Company afforded him adequate support for the remainder of his life.

Although entirely self-taught, Mr. Wilson's attainments were of no common order. He was not only well versed in the mathematical principles of natural and experimental philosophy, in illustration of which he, in conjunction with his friend Mr. Stevens, constructed a great variety of ingenious apparatus, admirably adapted to explain and demonstrate those principles to an audience, but he was an excellent chemist, as may be seen by a reference to an important series of experiments on the explosive compound of chlorine and nitrogen, then newly discovered, which in the year 1813 he undertook, in conjunction with Messrs. R. Porrett and Rupert Kirk, an account of which is published in the thirty-fourth volume of Nicholson's *Journal of Natural Philosophy, Chemistry, and the Arts*. He was also a botanist and mineralogist, and formed a large collection of objects for the microscope, mounted with his own hands. In short, there was scarcely any portion of the science of his day to which he had not applied himself



with success. He was much and deservedly respected by the members of the Mathematical Society, as he was at all times ready to communicate any information in his power to an inquirer, and endeavoured to render such information as intelligible as possible. For many years he was the senior member of that Society, but never filled the office of President. He became a Fellow of this Society when the junction of the Mathematical Society with it took place in 1845. He died in January, 1861, in his ninety-third year.

PIERRE DAUSSY was born at Paris, October 8, 1792; his father was what he afterwards became, *Ingénieur Hydrographe*. While engaged in the school of hydrography, he studied astronomy in theory and practice at the observatory of the *Ecole Militaire*, under Burckhardt. From 1810 to 1814 his time was mostly devoted to astronomy. His occultations were published in Zach's *Correspondance*. He calculated the orbits of the second comets of 1814 and of 1737. In 1813 he presented to the Institute a memoir on the perturbations of *Vesta*, which gained the Lalande medal. A second and more extensive memoir on the same subject was published by the Bureau des Longitudes in the *Connaissance des Temps* for 1818; and tables founded on the elements therein contained were published in the same work for 1820.

From 1816 to 1826 Daussy was employed in triangulations which extended along the coast from Brest to Bayonne, thus joining the whole coast to the great triangulation. Puissant spoke in high terms of the execution of this work, and states that its agreements with the larger triangulation show the two to be parts of one whole. The *précis* of the whole was published in 1829, at the end of the *Exposé des Travaux, &c.*, of M. Beautems-Beaupré. In 1829 he was employed in the connexion of the Channel Islands with the coast near St. Malo, at which time he also paid special attention to the local tides, on which he published two memoirs in the *Connaissance des Temps* for 1834 and 1838. His researches led him to the discovery, since verified by others, of the variation of the mean level of the sea with the height of the barometer.

It is not our place to follow Daussy through the long train of purely geographical labours by which he bore his part, and no small one, in raising the French school of hydrography to a high pitch of reputation and of utility to the whole world. An excellent account of the whole, though short, will be found in the notice by M. de la Roquette, inserted in the 20th volume (4th series) of the *Bulletin de la Société de Géographie*. He died September 5, 1861. His personal character was of the highest, and he was respected accordingly. Of the various marks of consideration which he received, the one which is now best worth noting is, that he was President of the Geographical Society of Paris. He was of the Institute of the Legion of

Honour, Astronome Adjoint of the Bureau des Longitudes, &c.

Just as this Report was ready for the Meeting news arrived of the death of Jean Baptist Biot, the oldest Associate of the Society, and the last of the celebrated *savans* of what he himself called the first edition of the French Republic. M. Biot would have been 88 years old if he had lived two months longer; and to the last he was actively employed. In November, 1861, he completed an elaborate survey of Chinese Astronomy for the *Journal des Savants*. Biot was alive in the time of D'Alembert and Voltaire, with either of whom, as a child, he might have talked; thus, better than by dates, we gain a notion of the long period through which he lived. It is necessary to defer until next year all detail of the labours of this distinguished cultivator both of science and letters.

In the ordinary operations of the Royal Observatory, Greenwich, very few changes have been introduced during the year 1861. The observations are of precisely the same character as before, and the reductions have been made to keep pace with the observations. The volume for 1860 has been very nearly passed through the press. The formation of a catalogue, embracing the star-observations from 1854 to 1860, is vigorously progressing.

The Great Equatorial has been principally employed in observations of *Jupiter* and *Saturn*. A connected series of drawings of these planets has been made. The instrument has also been employed in observations of Comet II., 1861.

It has been known for several years that interruptions of communications by the Galvanic Telegraph occur, from time to time, produced by spontaneous galvanic currents passing through wires whose extremities are connected with the earth. Arrangements have now been made, and the works are in progress, for the self-registering of these earth-currents at the Royal Observatory. A grant for this purpose has been made by the Admiralty, and the arrangements have been much facilitated by the liberality of the Directors of the South-Eastern Railway, along whose lines the wires are to be carried, and by assistance rendered, in several ways, by their indefatigable Superintendent of Telegraphs, C. V. Walker, Esq.

The observations of the Royal Observatory, Edinburgh, are printed to the end of 1859, and in the Meridian Department are being continued as usual, or, it is hoped, with more than usual accuracy, in consequence of the successful completion during the last year of a long series of experiments which have been carried on during many years with the view

of removing some acknowledged defects from the sidereal clock—a most vital part of a meridian observatory.

The Astronomer's attention had long been called to the subject on account of the double evils,—1st, of minute changes of rate, dependent on small and rapid variations of temperature ; and, 2d, of inaudibility of the seconds' ticks in the high winds of an exposed hill-top. Each of these difficulties has now been overcome with as much completeness as if the other had had no existence, although at first they appeared to require antagonistic applications ; and the result is, that the *time-keeping* department of the old transit-clock has been confided, pure and simple, to a clock (that which was presented to the Observatory by the late Sir Thomas Brisbane) enclosed, at a distance from the transit-instrument in a closet, in a covered part of the Observatory, tending to equal temperature (in the manner of the position of the Normal Clock at the central Observatory of Pulkova) ; but the *observing* department of the same old transit-clock is now taken up by a different clock altogether, and one the whole mechanical arrangements of which are devoted to enabling the seconds to be seen and heard by the observer at both the transit-instrument and mural circle, as easily and powerfully as possible ; while its rate of going is taken electrical charge of by the other, or the time-keeping clock in the dark closet. By means of a small tilt-hammer, which strikes at every second on the outside of the case of the observing-clock, the audibility of the seconds tick seems carried to the highest desirable point ; and by Mr. Jones' (of Chester) method of electric controlling, the required action of galvanism has been attained with invariable certainty, and at the smallest current expense for electricity that can well be conceived, as is judged after the experience of about nine months.

Almost simultaneously with the improvement of the sidereal-clock system of the Observatory, a considerable extension of its duties took place with regard to its mean-time arrangements ; for the public of Edinburgh, no longer content with a visible signal of the true time daily, demanded an audible signal of it as well, in the shape of a cannon fired from the Castle of Edinburgh by electric influence from the Royal Observatory, Edinburgh ; and having raised voluntary subscriptions to pay all expenses, except those incurred at the Observatory, they procured the necessary authorisation from Government to carry out the work. The mechanical arrangements have been carried out with much precision.

Amongst the extra duties of the Observatory, the reduction, for the Registrar-General of Births, Deaths, &c. in Scotland, of meteorological observations from fifty-five meteorological stations in the North, still goes on, and occupies much time.

During the last severe winter and spring the health of

the Astronomer and Assistants suffered so much, that the Board of Visitors was induced, during the summer, to take up the important subject of suitable accommodation for the observers, but were not able to come to any practical result at present. The official house of the Astronomer is not only at a considerable horizontal distance from the Observatory, but at a lower level by so much as two hundred and forty feet vertical: the labour of such a journey, by both night and day, and through all seasons of the year, is enough to sap the health of any one, especially when it is remembered to engage in what sort of sedentary computing occupation the chief part of the ascents are made.

At the Radcliffe Observatory, Oxford, the arrears of the printing of the Observations have been lessened by the publication of the nineteenth volume of the *Radcliffe Observations*, and the reductions have been carried on with sufficient vigour to ensure the speedy publication of another volume, containing the Observations of 1859 and 1860. The printing of the Observations of 1859 is nearly completed.

Throughout the year 1861 the meridian observations were made as before with the transit instrument and meridian circle, the chief subject of observation being the completion of Mr. Johnson's Catalogue of Remarkable Objects. In the summer, however, of 1861, there was purchased, with the consent of the Radcliffe Trustees, the transit circle belonging to Mr. Carrington, which had been used with such good effect by him at Red Hill. Mr. Main himself superintended the mounting of it at Oxford on the same piers that were used at Red Hill, and the whole was successfully accomplished considerably before the end of the year. Actual observations were commenced with it at the beginning of the present year, the chief subject of observation being the stars visible there between the fifth and the seventh magnitudes. In addition, the Sun is observed, and the Moon till opposition, together with some of the large planets, and such of the minor planets as can be seen with the telescope, of which the diameter is 5 inches.

With the heliometer Mr. Main has been engaged with the observation of a catalogue of double stars, and has already observed considerably more than one hundred. *Jupiter* and *Venus* have been also well measured. A long series of observations of the Great Comet of 1861 was also made, and the results have been communicated to the Society, and are printed in the December Number of the *Monthly Notices*.

The Photographic Meteorology has been well kept up as in former years, but with a diminished staff since August last. The only assistants employed at the Observatory since that time are Mr. Quirling and Mr. Lucas; and it is due to the energy and zeal of those gentlemen to state, that so large an

amount of work could not be done without the most incessant exertions on their part. The Observatory has, in addition, the advantage of Mr. Luff's services as a computer; and these have been most valuable and useful.

It may be considered that the prospects of the Radcliffe Observatory for the future are encouraging. It is now adequately supplied with excellent modern instruments, which are employed effectively for useful purposes; and, though the staff of assistants is small, it will probably be found, by economy of labour, adequate to the carrying out the views of the Directors, and to the sustaining of the past reputation of the Observatory. We are sure, moreover, the Society will duly appreciate the enlightened liberality of the Trustees, in purchasing without hesitation the Carrington Transit-Circle, as soon as it was explained to them that the demands of science at the present time required the establishment of an instrument of that class.

The Observatory of Cambridge is at this moment in the state which necessarily arises from a change of superintendence, and, to some extent, of system. Professor Challis discontinued residence at Michaelmas, and Professor Adams is on the point of commencing residence, having been in charge since Mr. Challis left. The interval has been employed in making some alterations which would, perhaps, hardly be thought worthy of mention, but both gentlemen speak so strongly of the improvement effected, that notice may be taken of them in illustration of the importance of little aids to convenience. The calculating-room had been intended to receive an instrument, and the slits in the sides and roof gave it that tendency to equality of temperature with the outer air which promotes observation more than calculation. The Superintendent's private room was also a thoroughfare.

By aid from the Sheepshanks' fund, Mr. Challis completed the reduction of all the meridian observations made under his care, and also made some progress in the final reduction of the equatoreal observations. The printing is about to be commenced. A long and good series of the conspicuous comet of July last was carried to nearly the end of the year: the publication awaits the determination of some of the comparison stars. The transit of *Mercury* and the Solar Eclipse were hidden by clouds.

Mr. Adams, without having settled details of plan, intends to take up some definite class of observations, of not too extensive a character for his staff, and to discuss the results: without binding himself to engage largely in the routine observations which are sufficiently attended to at Greenwich. This plan he takes to be most fitted to create and keep up in the University a spirit of astronomical inquiry, one of the chief objects for which the Observatory was founded.

The University Syndicate, after paying a well-merited compliment to the long and able services of Mr. Challis, rejoice that the Observatory has still the advantage of his official connexion with it as Plumian Professor. In this the Society will join; and the astronomical world will look forward to good results from the union of the efforts of Mr. Adams and Mr. Challis, with the power of obtaining subordinate labour which the Sheepshanks' fund is likely to add.

When the Astronomer is far removed from the society of his scientific colleagues, events of his domestic life may become legitimate objects of mention in our Report, in all cases of which the Fellows would desire to convey the expression of sympathy. The zealous Astronomer of the Cape of Good Hope will feel assured of the sincerity with which the Society expresses its regret at the death of Lady Maclear.

Encke's Comet was found at the Cape early in December. To use Sir T. Maclear's words, "it comes up sharp to the predicted orbit." It was, however, too faint for good observation when the last letters were received.

The extensive alterations and improvements at the Liverpool Observatory are now completed, and Mr. Hartnup is again at work with the Equatoreal. The new arrangements for testing and rating chronometers are much admired by all who have seen them, and fully answer Mr. Hartnup's expectations. The results of the first trial of chronometers with the new arrangements have been published in the *Horological Journal*. The new room having been found too large for the normal clock to be heard distinctly in every part, another clock has been added and successfully controlled by Mr. Jones' method, so as to produce perfect coincidence of beat with the normal clock. This new clock has a dial, twelve inches diameter, and a seconds' hand only, the minute and hour hands not being required; it is controlled with the same current which is used for working the relays in connexion with clocks in different parts of the town, and the battery power is, consequently, excessively great in comparison to the driving power. On first starting this clock, the beat, with the current on, soon fell behind that of the normal clock from one to two-tenths of a second, and remained so till the pendulum of the controlled clock was shortened, so as to make it gain a little; the coincidence was then found to be perfect, and it has required no alteration since. Mr. Hartnup states that when the escapements and pendulums of these clocks are made under the direction of the inventor and patentee, there is no danger of stopping them by reversing the current or applying it at the wrong time, as he has repeatedly tried the experiment with the small clock above named, and also with the large clocks in the town, one of which has six dials of eight feet diameter

each. The Town Hall clock, which has four dials, formerly went very irregularly, and sometimes stopped during high winds, frost, or snow; but since it has been controlled from the Observatory, the severity of the weather has neither stopped it nor interfered with the regularity of its performance.

All the public clocks belonging to the Dock Estate are now placed under the management of Mr. Hartnup, and a man is attached to the Observatory to look after them. Of all the methods which have been adopted in Liverpool for the dissemination of accurate time, the seconds' clock, which is controlled from the Observatory, appears to be the most highly appreciated by the public. This clock is placed in the office-window of the Magnetic Telegraph Company, and can be seen from the Exchange flags. On the 4th February, 1861, the Secretary of the Telegraph Company caused the number of persons to be counted, and between 6 A.M. and 5 P.M., 1860 persons compared watches or chronometers with this clock. The seconds' clock above named makes contact every minute at the sixtieth second, and a current is returned to the Observatory to show that it is correct. In addition to this, an arrangement has recently been made by the Engineer of the Magnetic Telegraph Company, at the suggestion of Mr. Hartnup, by which the return current can be passed on to London.

Attached to one of the Liverpool instruments there is a switch, which, when turned, prevents the clerk from working, and leaves the wire exclusively to the clock; so that at any time, day or night, when the wire is not wanted for ordinary work, London can receive time-signals from Liverpool every minute, and the errors arising from dependence on a single current are in this way avoided.

The meteorological work of the Observatory has, Mr. Hartnup says, been much heavier during the past year than heretofore. The Underwriters are beginning to take more interest in this department, the efficiency of which will shortly be greatly improved by the addition of a self-registering barometer of a novel construction.

Professor Grant reports that, at the Glasgow Observatory, attention is chiefly devoted to the reobservation, with the Meridian Circle, of a selection of stars in the British Association Catalogue ranging between the sixth and eighth magnitudes. It is also contemplated to include in the list of objects for observation some of the smaller stars of the Armagh Catalogue which have been found to exhibit a considerable proper motion. Negotiations are at present in progress for supplying the Observatory with an equatorially-mounted refractor of considerable dimensions. The Town Council have finally decided upon laying down a wire between the Observatory and several of the

city clocks, with the view of having the latter controlled by the application of Jones's electro-magnetic method. In all probability a similar connexion will shortly afterwards be established between the Observatory and the time-ball which is daily dropped for the use of the shipping in the Clyde.

With respect to the proceedings of the Hartwell Observatory during the last year, since the departure for Madras of Mr. Pogson, who was observer from December 1860, little of interest to the public has been done.

Mr. Pogson is busily engaged in preparing the Hartwell and Madras Atlas of Variable Stars, at moments when not occupied by his public duties as Astronomer at Madras; and his situation in the Observatory at Hartwell has not been filled. Meanwhile the several instruments are at the disposal of Admiral Smyth and Captain Jacob.

Among other observations, Encke's Comet was picked up by Mr. S. Horton, the Assistant, on the 24th, 26th, and 30th of last November.

Mr. Lassell writes from Malta that he has succeeded in the perfectly successful erection of the 4-foot equatoreal, on a favourable site near Fort Tigné, on the north side of the Quarantine Harbour. The whole was effected without any accident, either in transmission or erection; and the mirror now in use, when its coat of varnish was dissolved and removed, came out as fine in lustre as if it had been just polished. Mr. Lassell now feels that he has such an instrument as he never had before, and he begins to be dissatisfied with his previous drawings. Some remarks on the performance of his telescope, and the discovery of a new star in the trapezium of the great nebula of *Orion*, will receive due attention at the next ordinary meeting of the Society.

Mr. Balfour Stewart, Director of the Kew Observatory, states that during the past year several experiments were made at Mr. De La Rue's request, to ascertain whether any advantage resulted by increasing the aperture of an object-glass beyond that found adequate to the production of a good sun-picture. The aperture of the heliograph was cut down by stops to 2 inches, and gradually increased to the full aperture of $3\frac{1}{4}$ inches; but it was not found that increase of aperture showed more details or gave a sharper image than with the 2-inch diaphragm. Preparations were made for photographing the transit of *Mercury* on November 11; but, unfortunately, the day proved hopelessly cloudy, and the Sun was not visible.

From November 7th to 20th, a very complete series of solar photographs were obtained, which have been placed in Mr. De La Rue's hands for measurement with his new instrument. They are thirty-six in number, and of great beauty,

showing the minute details on the Sun's disk with remarkable precision. They render evident the capabilities of the instrument, and the command of it possessed by Mr. Beckley.

Only two pictures could be obtained of the partial eclipse of December 31, in consequence of the clouded state of the sky and a thick mist which obscured the atmosphere; each of the pictures required an exposure of several seconds. With the instantaneous apparatus not the slightest trace of an impression was formed.

Since the 31st December the optical part of the heliograph has been removed from the stand and transferred to Mr. De La Rue's Observatory at Cranford, that gentleman having undertaken to register the Sun's disk by means of the Kew instrument.

At the Observatory, Cranford, a series of experiments has been made with the view of obtaining photographic pictures of the Sun's surface on a very large scale, in order to show the details of the spots and other markings with sufficient distinctness to render evident the changes which take place in them. After many trials, which at first gave very little promise of success, Mr. De La Rue succeeded in procuring pictures of the Sun on a scale of 36 inches to the Sun's diameter. The plates actually used were not more than 18 inches square, so that only a portion of the solar disk could be depicted at each operation. At the November Meeting these photographs were described, and several were distributed to the Members present; and it was stated that, by taking two views of the same sun-spot at an interval of several hours, they could be advantageously studied with the stereoscope, which rendered evident the relative positions of the several parts in regard of altitude and in other respects. In this way Mr. De La Rue had obtained a proof that the faculæ occupy the highest regions of the Sun's photosphere; the spots appearing as holes, in the penumbra which inclined in some cases downwards, funnel-like, from the brighter parts of the Sun's disk; portions of faculæ could also be made out to be sailing high above over the spots and penumbra.

Mr. De La Rue states that he has been much occupied during the past year in measuring the photographs procured of the eclipse at Rivabellosa in 1860, by means of a new measuring instrument, and that the results obtained show that photography is capable of yielding the most accurate numerical data, as well as of depicting the physical features of astronomical objects.

The tube of the Kew heliograph is now mounted on an out-rigger affixed to the declination axis of his large Equatoreal, and is for the present under the charge of his photographic assistant, Mr. Reynolds.

Several drawings of Comet II. 1861, have been made, but all attempts at photographing it completely failed; not only was no impression procured with the reflector, but even with a short focus portrait-lens and an exposure of the sensitive-plate during 15 minutes, not the slightest trace of the comet could be obtained; the stars in its neighbourhood imprinting themselves perfectly.

Professor William Selwyn, of the College, Ely, has, by means of a small instrument constructed by Dallmeyer, on the plan of the Kew heliograph, procured some very good solar photographs. Unfortunately, the instrument has no position-wire, so that there was no means of determining the co-ordinates of the spots.

M. Faye communicated to the Académie des Sciences in December last, that he had succeeded in obtaining, photographically, a complete series of transit observations of the Sun, and of registering the exact moment of the production of each image by means of electro-magnetism. An assistant, in exposing the plate, at the same time brought into action the electro-magnet, but M. Faye points out that the assistant may be replaced by an automatic apparatus connected with the transit clock. In this way a plan, suggested as possible in 1849, and in part carried out by M. Liais, a French astronomer, who formed one of the Brazilian expedition to observe the total eclipse of 1858, has been finally brought to a successful issue by M. Faye.

M. Vernier of Belfont obtained six photographs of the eclipse of December 31st last; these photographs were each procured in a small fraction of a second, notwithstanding which, and also the sky being perfectly clear at the time, in four of the photographs the Sun's image is surrounded by a halo, which M. Vernier appears to consider as in some way appertaining to the Sun. No such halo surrounds the Sun's image in the Kew photographs, the negative impression of the Sun standing out on a perfectly transparent background. Most probably, therefore, the halo is due to irradiation or to over-exposure, when our atmosphere in apparent contiguity with the Sun will imprint itself.

Mr. Dallmeyer is under Mr. De La Rue's direction constructing a Heliograph, ordered by M. Otto Struve for the Russian Government: it is destined to be placed in the Observatory of Wilna. Messrs. Simms are also making one of Mr. De La Rue's measuring instruments, to be used in connexion with this heliograph.

From the attention which astronomical photography is attracting, it is likely that it will soon be adopted as one of the means of recording phenomena in some of the government Observatories, and that more especially sun-observations will

be made by it, from the circumstance that sun-pictures are obtainable with great facility and instantaneously.

Professor Kaiser, Director of the Observatory, Leyden, has intimated that a new Observatory on a grand scale has been recently completed at Leyden, and supplied with excellent instruments; although not yet in full activity, some experiments have been already made by Mr. P. T. Kaiser, son of the Director, having for their object the application of photography to astronomy. The instrument employed was the new 7-inch Munich refractor by Merz, and some lunar photographs have been taken with it, which, however, in consequence of the driving clock of the instrument not having sufficient power, are not so perfect as could be desired.

The erection of telescopes in more favourable situations than British islands afford, has received increased attention of late years, as evinced by the expeditions of Prof. Smyth to Teneriffe, and of Mr. Lassell to Malta. A proposal made about ten years ago, to erect a reflector of the largest dimensions in Australia, proved abortive from the difficulty of finding the corresponding Observer. A little later, however, another scheme was the subject of much correspondence between certain Fellows of this Society, which was principally suggested by the destruction of the Observatory at Lucknow, and the confirmed unhealthiness of Madras, and the presence at the head of the India Board of a nobleman with whom the motives of astronomical enterprise would find appreciation, and such aid as his department could afford. The social and financial disturbances caused by the Indian Mutiny, however, prevented progress at that time with any prospect of success. But, during the past year, the subject was brought definitely before the Council of the Society in the form of an offer by Capt. Jacob to provide an Equatoreal of high excellence, to transport it to a hill station near Poonah, and work it in that admirable climate at an elevation of nearly 5000 feet above the sea for three years, provided certain of the heavier incidental expenses were provided for by the exertion of the influence of the Council. The offer was accepted after consideration by a Committee, and application for a grant of public money was made to the First Lord of the Treasury, and by whom the sum required was submitted to Parliament and voted very shortly after, as the letter recently printed in the *Monthly Notices* has already shown. The required assistance being thus readily promised, it remains to state that the Council expect as the result, not a mere record of tests showing the degree of excellence of the climatic conditions obtained, but some considerable additions to the details of the physical scrutiny of celestial objects, which may induce other observers of independent position to regard a good climate of equal im-

portance with a good telescope, and to go wherever it may be necessary to find it. The success of the enterprise will depend very much on the health of Capt. Jacob, who is expected to set out very shortly, and who will carry with him the good wishes of all who know him.

There was laid on our table within the year, as a present from the author, a short treatise "On the Motions of Fluids and Solids relative to the Earth's Surface," by W. Ferrel, Assistant upon the American Ephemeris. The work is intended to show that a complete mathematical investigation, setting out with the general equations of motion, leads to the same conclusions which were arrived at by the author previously, in a tract in which mathematical formulæ were avoided, and of which the subject was the modifying influence of the Earth's Rotation on the General Movements of the Atmosphere. The work belongs rather to meteorology and general physics; but it is possible that, by a slight extension of his investigation, the author might bring it within the department of physical astronomy, and contribute to our theoretical knowledge of the phenomena of the Sun's surface. The expression of our wish that he may resume the treatment of his problem under this other aspect, may induce him to earn our thanks by looking into another collection of observed facts, which much requires theoretical aid.

An immense addition has lately been made to our store of registered positions of stars, by the publication of the two first sections of Dr. Argelander's Bonn Catalogue, the first containing about 111,000 reduced positions, and the second about 105,000. A third section, which is already fully written out and in the printer's hands, will complete this great work. The corresponding charts, which Dr. Argelander has well regarded as necessary accompaniments of a Catalogue, are published to about the same stage of progress. Of the beauty of arrangement and execution of both Catalogue and Charts it is difficult to speak with moderation: to our view they are the perfection of astronomical workmanship in the branch they belong to. As very often happens, the execution of one work creates the necessity of another; and what has been for some time clear to a few will shortly be, if it is not now, plain to all, that what Argelander has done for the Northern hemisphere of stars must forthwith be done for the Southern. The plan is perfectly defined by his example, the limits of time and money equally so, and little else remains than to see whether an unofficial astronomer will seize the opportunity of distinction, or whether the Council of this Society, or some official Astronomer of this or a foreign country, shall take up the second half, and associate himself

with the veteran astronomer of Bonn in the crowning work of his life. Fellows of the Society will recollect that a report of this work was given by Argelander's desire in our number for December last.

The group of minor planets has received an accession of nine new members since the last Annual Meeting of the Society. The first, *Ausonia*, was discovered at Naples on the 11th of February by Professor De Gasparis; the second, *Angelina*, at Marseilles on the 6th of March, by M. Tempel; the third, *Maximiliana*, at Marseilles on the 10th of March, by M. Tempel; the fourth, *Maia*, at the Observatory of Harvard College, U.S., on the 10th of April, by Mr. Tuttle; the fifth, *Asia*, at Madras on the 18th of April, by Mr. Pogson; the sixth, *Leto*, at Bilk on the 29th of April, by Dr. Luther; the seventh, *Hesperia*, at Milan on the 29th of April, by M. Schiaparelli; the eighth, *Panopea*, at Fontenay-aux-Roses on the 5th of May, by M. Goldschmidt; the ninth, *Niobe*, at Bilk on the 13th of August, by Dr. Luther. The aggregate number of bodies in the group now amounts to 71.

Three new comets have been discovered during the past year. The first was discovered at New York by Mr. Thatcher. A parabolic orbit has been found to satisfy the observations. The second comet of the year must be regarded as one of the most splendid of modern times. It was first seen generally throughout Europe on the evening of the 30th of June, but it was subsequently found to have been seen as early as the 13th of May by Mr. Tebbutt, an amateur astronomer residing in New South Wales. During the first few nights after it became visible in Europe, the head shone with extraordinary splendour; the tail, also, exceeded 100° in length. In consequence of the unfavourable season of the year at which it appeared, it soon ceased to form a conspicuous object in the heavens; but it continued for a long time to be visible in telescopes even of moderate power. Several computers have formed elliptical elements for its orbit; but until the totality of the observations shall have been subjected to a complete discussion, no trustworthy results can be arrived at. The third new comet, announced since the last Annual Meeting of the Society, was discovered on the 29th of December at the Observatory of Harvard College, U.S., by Mr. Tuttle. It is still faintly visible as a telescopic object. A parabolic orbit appears to satisfy the observations.

Papers read before the Society from February 1861 to February 1862.

1861.

- Mar. 9. Note on the Appearance of *Jupiter's* fourth Satellite during Transit. Mr. Burr.
 Auxiliary Tables for Computing Log. Sine and Log. Tang. of Small Arcs. Mr. Drach.
 On the Theory of the Regulation of Clocks by Galvanic Currents acting on their Pendulums. Mr. Airy.
 On the Lunar Theory. Sir John Lubbock.
 On the Appearance of *Jupiter's* third Satellite during Transit. Mr. Gorton.
 On Prof. Wolf's latest Results on Solar Spots. Mr. Baxendell.
 Results of Observations of Minor Planets. Mr. Airy.
 On the Binary Star α *Cassiopeiæ*. Mr. Powell.
 On a Method of Determining Longitude without a Clock. M. Radau.
 Extract of a Letter to the Astronomer Royal. M. Hansen.
 On a Solar Spot. Mr. Nasmyth.
 Results of Observations of Solar Eclipse of 1860. Mr. Airy.
 On the Persistency of two Light Patches in a Solar Spot. Mr. Birt.
 On the Apparent Rotation of a Solar Spot. Mr. Birt.
- April 12. Observations and Elements of Comet III. 1860. M. Moesta.
 Morning Illumination of certain unnamed Lunar Craters. Mr. Birt.
 On a Remarkable Appearance in *Jupiter*. Mr. Birt.
 On a Micrometric Diaphragm. Mr. Casella.
 Observations of *Saturn*. Mr. De La Rue.
 Note on some Photographs of the Total Eclipse. Mr. De La Rue.
 Extract of Letter to Rev. R. Main. M. Winnecke.
 On Miscellaneous Subjects. M. Hansteen.
- May 10. On a Remarkable Appearance of *Jupiter*. Mr. Barneby.
 Observations of Small Planets, &c. Mr. Airy.
 Discovery of a Comet (Thatcher's). Mr. Parkin.
 Occultations of Stars by the Moon. Capt. Noble.
 Note on one of the Comites of β *Geminorum*. Rev. T. W. Webb.
 Morning Illumination of *Mare Humorum*. Mr. Birt.

- Minima of Short-Period Variable Stars for 1861.
 Mr. Pogson.
 Observations of Solar Eclipse, January 1861. Mr. Scott.
 Announcement of Thatcher's Comet. Mr. Lassell.
 Ditto ditto Sir J. Herschel.
 Phenomena of *Jupiter's* Satellites. Rev. R. Main.
 Letter to Dr. Lee, Discovery of *Leto*. M. Luther.
 Observations of Thatcher's Comet. Mr. Gorton.
 On the Secular Acceleration of the Moon's Mean Motion. Prof. Donkin.
 Observations of Thatcher's Comet. Prof. Mitchell.
 Observations on Prof. Hansen's Letter. M. de Pontécoulant.
 Places of Comet I. 1861. Dr. Robinson.
 Elements and Ephemeris of ditto. Mr. Pape.
 On the Spiral Structure of the Great Nebula of *Orion*.
 Mr. G. P. Bond.
 On the Light of the Sun, Moon, *Jupiter*, and *Venus*.
 Mr. G. P. Bond.
 Observations of Small Planets. Mr. Airy.
 On an Appearance observed in *Jupiter*. Mr. Baxendell.
 Observations of Thatcher's Comet. Comm. Maury.
 Discovery of New Planet (*Asia*). Mr. Pogson.
 On the Shadow of the Ring of *Saturn*. Capt. Jacob.
 Ditto ditto Mr. Lassell.
 Observations of Small Planets, &c. Mr. Airy.
 On the Variation of *Argus*. Mr. Abbott.
 On the Probable Identification of Anthelm's Variable of 1670. Mr. Hind.
 On the Nomenclature of the Minor Planets. Mr. Hind.
 Occultations observed at Highbury. Mr. Burr.
 On the Penumbra of a Solar Spot. Mr. Birt.
 Nov. 8. Observations of a Comet (Tebbutt's), &c. Commander Maury.
 Table of Path of Moon's Shadow, Solar Eclipse, 1861.
 Mr. Hind.
 Observations at Sea of a Comet. Mr. Krabbe.
 On an Instrument for Comparing Colours. Mr. Birt.
 Observations on *Cichus*, a Lunar Crater, &c. Mr. Birt.
 Development of Horary Formulæ. Mr. Drach.
 On the Form of the Shadow of *Saturn's* Ring. Rev. T. W. Webb.
 On the Positions of the Radcliffe Catalogue. Mr. Safford.
 Observations of Comet II. 1861. Mr. Ferguson.
 Ditto ditto Mr. Abbott.

- Observations of Comet II. 1861. Mr. Scott.
 Ditto ditto Mr. Hough.
 Ditto ditto Mr. Burder.
 Ditto ditto Dr. Stothard.
 Ditto ditto Mr. Tidmarsh.
 Ditto ditto Mr. Carpenter.
- Observations of Solar Spots. Major Lang.
 Places of Comet II. 1861. Mr. Mansell.
 Observations of Comet III. 1860. Sir T. Maclear.
 Ephemeris and Elements of Encke's Comet. M. Encke.
- On a Result derived by M. D'Abbadie from Observations of the Total Solar Eclipse, 1860. Mr. Airy.
 On a new Observing Clock. Prof. C. P. Smyth.
 Observations of the Lunar Crater *Plato*, with a volume of Drawings. Mr. Birt.
- Extract of Letter to the Astronomer Royal. Mr. Hansen.
- Occultation observed at Highbury. Mr. Burr.
 Observations of Solar Spots, with Drawings. Rev. F. Howlett.
- On a Proposed Isolated Flange for Conical Axes. Major Strange.
- On Testing the Vertical Axes of Altazimuth Instruments. Major Strange.
- On a Direct Method of Testing and Adjusting the Eye-piece of Altazimuth Instruments. Major Strange.
- Dec. 13. On Solar Radiation. Mr. Waterston.
- Right Ascensions and Declinations of Fundamental Stars observed at the Radcliffe Observatory, compared with the *Tabulæ Reductionum*. M. Wolfers.
- Variations in the Light of *Argus*. Mr. Powell.
- On an Observed Minimum of *R Vulpeculæ*. Mr. Knott.
- Note accompanying two Drawings of *Saturn*. Capt. Jacob.
- On an extraordinary Solar Phenomenon. Mr. Wood.
- Extract of Letter to Admiral Smyth. Mr. Spratt.
- Extract of Letter to the Astronomer Royal. M. Secchi.
- Observations of Comet II. 1861. Mr. Hartnup.
- Transit of *Mercury*, Nov. 11, 1861. Mr. Hartnup.
 Ditto ditto Mr. Lassell.
 Ditto ditto Mr. Jeans.
- Results of Observations of Small Planets. Mr. Airy.
- Occultations observed at Maresfield. Capt. Noble.
- On the Egyptian Period of 540 Years. Mr. Cooper.
- Observations of Encke's Comet and *Saturn*. Mr. Horton.

- On the Secular Acceleration of the Moon's Mean Motion. Mr. Cayley.
On the Transit of *Mercury*. Mr. Baxendell.
Observations of the Great Comet of 1861. Rev. R. Main.
On the Transit of *Mercury*. Rev. Prof. Chevallier.
1862. On the Progress of the Bonn Charts. Mr. Carrington.
Jan. 10. On the Circularity of the Sun's Disk. Mr. Airy.
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On the Solar Eclipse, Dec. 31, 1861. Lieut. Hardy.
Third Memoir on Disturbed Elliptic Motion. Mr. Cayley.
Note accompanying Photograph of the Sun. Mr. Selwyn.
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List of Public Institutions and of Persons who have contributed to the Society's Library, &c. since the last Anniversary.

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Photographic Society.
Society of Arts.
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 The University of Christiania.
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Sir J. W. Lubbock.	Mr. J. Williams.
M. Mailly.	M. Winnecke.
Sen. F. de P. Marquez.	Dr. R. Wolf.

Address delivered by the President, Dr. Lee, on presenting the Gold Medal of the Society to Mr. Warren De La Rue.

Gentlemen,—In the Report which has been read to you, you have been informed that the Council have assigned the Gold Medal of the Society to our worthy Secretary, Mr. Warren De La Rue; and, as it is the custom, it becomes now my duty to explain to you, in a few words, the grounds of their decision.

You know that for many years Mr. De La Rue has devoted

on its centre, by governing that rotation by mechanism, instead of leaving it to be determined by the excess of external over internal friction."

But it is in Celestial Photography that Mr. De La Rue has made his most important discoveries, and displayed an unfailing fertility of mechanical invention. Wisely acknowledging the growing vastness of the several departments of the same science, he has latterly, in a great measure, restricted his researches to the delineation of the various aspects of the heavenly bodies, through the medium of Photography.

It is only by acknowledging and adopting the principle of the division of labour that great results can be obtained, either in the pursuits of commercial industry or abstract science.

The days of the Admirable Crichton have long since passed away.

Indeed Lord Bacon himself, in the *Novum Organum*, well observes, in anticipation of the influence of this general principle:—

"Then men shall begin to find out their own powers, when all will not essay to do the same things, but each man will employ himself in the work for which he is most apt."*

Mr. De La Rue's claim to the special notice of astronomers, as a delineator of celestial objects through the medium of photography, does not rest on the absolute priority of his application of a well-known art in a new direction. It is rather based on the fact, that by methods and adaptations peculiarly his own, he has been the first to obtain automatic pictures of the Sun and Moon, sufficiently delicate in their detail to advance our knowledge regarding the physical characters of those bodies, and admitting of measurements astronomically precise.

The late Mr. Bond, of Cambridge, in the United States, in the year 1845, with the assistance of Messrs. Whipple and Bond, obtained good pictures of *α Lyrae* and of *Castor*; and that, in this year, Signor De Vico made an unsuccessful attempt to photograph the nebulae in *Orion*.

At about the same time, or a little later, the Rev. J. B. Reade took photographs of *α Lyrae* at my Observatory at Hartwell, and at his own Observatory at the Vicarage of Stone.

Mr. Glaisher, writing, in 1851, as Reporter upon Philosophical Instruments in the Great Exhibition, Class X., and upon Mr. Bond's Daguerreotype of the Moon, taken in 1850, and which was placed in the Exhibition of 1851, says upon Photography,—“Let us now view Photography in its application to science: a process by which transient actions are rendered permanent, and which enables *Nature* to do her own work—or, in other words, which causes facts permanently to record themselves—is too well fitted for the purpose of science

* “*Tum enim homines, vires suas nosse incipient, cum non eadem infiniti, sed alia alii præstabant.*”—*Liber 1, Aphor. cxlii.*

to be long overlooked; but the difficulties to be overcome in its application have been and still are great, and the results proportionably few in number. We consider, however, that the commencement of a systematic application of the photographic process to the purposes of Astronomy is indicated by the daguerreotype of the Moon by Mr. Whipple; and great indeed will be the benefit conferred upon astronomical science when we obtain permanent representations of the celestial bodies and their relative positions through the agency of light."

Enlarged copies of Mr. Bond's photographs were laid before the Royal Astronomical Society in May of the same year. At the Meeting of the British Association of Science held at Ipswich in July 1851, under the Presidency of the learned Astronomer Royal, a daguerreotype of the Moon was shown to the members of the Mathematical Section by Mr. Bond; and his Royal Highness the Prince Consort, whose loss we now deeply deplore, was present on the occasion, and inspected the daguerreotype.

On the subject of the connexion of Photography and Chemistry with Astronomy, some interesting remarks appear in the admirable Lecture on the Sun, delivered by the respected Professor Walker before the British Association of Science under the Presidency of our esteemed Member Lord Wrottesley, in 1860, at Oxford.

There are several references to Celestial Photography in the various volumes of the *Comptes Rendus*, which can only be brought to your notice in the form of notes.*

It was the sight of these very promising daguerreotypes of Mr. Bond which, in 1851, first gave the impulse to Mr. De La Rue's labours in this direction. In 1852 he availed himself of the collodion process invented by Mr. Archer in the preceding year, and succeeded in obtaining a good picture of the Moon. In 1853 Professor Phillips obtained talbotypes of the Moon at York. In 1854 lunar photographs were secured at Liverpool under the supervision of our respected member Mr. Hartnup. In 1855 the Rev. J. B. Reade, who has distinguished himself by his discoveries in photography, obtained special notice

* 1849.—Vol. xxxviii. p. 241. "On the Observations of the Sun." By M. Faye.

1858.—Vol. xlv. p. 705 and following pages. "On the Photographs of the Eclipse of March 15, by MM. Porro and Quinet." By M. Faye.

1859.—Vol. xlviii. p. 174. "Report on a Memoir addressed by M. Liais on the occasion of the Total Eclipse of 1858, September 7."

1859.—Vol. xlix. "Second Memoir on the coming Eclipse of 18 July."

1860.—Vol. li. p. 965. "On the State of Astronomical Photography in France."

1861.—Vol. liii. p. 997. "On the Perfecting Meridional Observations of the Sun without an Observer." By M. Faye.

1862.—Vol. liv. pp. 43 to 159. "On Photographs of the Sun, taken by M. Belfort during the Eclipse of the 31st December last."

and honourable mention at the Paris Exhibition for his photograph of the Moon. Others, also, have been taken, at Rome by Signor Padre Secchi, at Brighton by Mr. Fry, and in the vicinity of London by Mr. Huggins. All these photographs possess merits of their own, and give decided promise of future and greater success.

Admiral Smyth, in the *Speculum Hartwellianum*, pp. 249-50 and 285, speaks of Mr. Bond's labour in Celestial Photography, particularly pointing out that, in 1857, a photograph was sent to the Astronomer Royal taking in the whole field between *Mizar* and *Alcor*, with such exactitude as to show their angles of positions and distances.

Mr. De La Rue's success in obtaining photographic pictures of the Moon possessing great sharpness of definition and accuracy of detail is owing to the happy combination of a variety of causes. Possessing a large mirror of such exquisite defining power that but few existing telescopes equal it in accuracy of definition, and brought into figure by *his own hands*, and by peculiar machinery of *his own contrivance*, he was at once freed from those imperfections in the actinic image which are of necessity inherent in the very best refractors, even when corrected most accurately for chromatic dispersion.

Mr. De La Rue at first had no clock-work apparatus to govern the motion of his telescope, and, after making several successful lunar photographs with the aid of the hand-gear of the telescope, he discontinued his selenographical experiments until he had removed from Canonbury to Cranford—a change of residence which, for the interests of Astronomy, he had for some time previously in contemplation. He then furnished his telescope—his own in a double sense—with a clock-work apparatus, which from time to time has passed through numerous alterations, and which is still in course of improvement. The mechanical problem before him, as the Fellows of this Society well know, was one of extreme complexity; for not only must the motion of the clock-work be perfectly smooth and equable, but it must also be capable of acceleration and retardation, to keep pace, so to speak, with the ever-varying velocity of the Moon in the heavens—a variation compounded of its diurnal motion and its ever-changing velocity in its orbit.

Lastly, by a rare and happy combination of chemical with mechanical skill, the time necessary for the exposure of the collodion film was materially shortened. The final result is this,—that images of the Moon have been repeatedly taken in the focus of the mirror, admitting of very considerable amplification, and exhibiting details on the Moon's surface sufficiently clear to admit of delineation under a microscope provided with a camera lucida, and thereby furnishing materials for a more accurate selenography than has heretofore existed.

Neither must we altogether omit that by stereoscopically

combining images of the Moon taken in different phases of her librations, more particularly enlarged copies eight inches in diameter, Mr. De La Rue has brought to light details of dykes, and terraces, and furrows, and undulations on the lunar surface, of which no certain knowledge had previously existed, and which I have had the exquisite pleasure of beholding in his Observatory at Cranford.

"Man looks aloft, and, with erected eyes,
Beholds his own hereditary skies."

I must now turn to a department in Celestial Photography, where Mr. De La Rue stands almost alone. I speak of *Heliography*. In April 1854, Sir John Herschel, in a letter to Colonel Sabine, recommended that daily photographic records of the Sun should be obtained at some observatory. Accordingly, the Royal Society placed at the disposal of the Kew Committee a sum of money to promote that object, and Mr. De La Rue was requested to administer the grant.

It becomes necessary to mention that Arago, in his elegant and popular work on Astronomy, translated by two eminent Fellows of our Society, states, that MM. Fizeau and Foucault, in 1845, obtained a photographic image of the Sun, and two spots on its disk, delineated with much apparent sharpness and accuracy; but, however this may be,* it is certain that no uniformly successful method of taking images of the Sun had been devised until Mr. De La Rue took up the problem for investigation.

Yet great as had been the difficulties in obtaining a really accurate and available picture of the Moon, they sink into insignificance when compared with those which had to be overcome in the photography of the Sun; for to obtain any automatic pictures of the Sun's photosphere available for practical purposes, it was found necessary to institute a series of preliminary experiments before actual operations could be successfully commenced. At first, nothing but burnt up and solarised pictures could be obtained by any method that had hitherto been devised, or with any the least sensitive of the media, that could be procured. Now, with the help of the Kew photoheliograph, as devised by him, and described in vol. xv. of the *Monthly Notices*, *heliography* is the easiest and simplest kind of astronomical photography. The method devised by Mr. De La Rue will enable any photographer of common average skill to take excellent heliographs. Pro-

* Respecting this photograph of the Sun, the Index of the *Comptes Rendus* has been searched all through, under the heads of Arago, *Photography*, *Soleil*, *Fizeau*, *Foucault*, *Daguerreotype*, and *Faye*, and no mention has been found whatever of the Sun's picture in 1845; and there has not been found any reference to it, excepting the plate in the body of the original work itself.

fessor Selwyn, of Cambridge, succeeds in getting good pictures of the Sun with the apparatus made for him by Mr. Dalmeyer, after the pattern of the Kew photoheliograph.

Mr. De La Rue announced at the last Meeting of the Society, that by applying the stereoscope to the examination of the Sun's disk, as he had formerly done in the case of the Moon, he had discovered that the faculæ on the surface of the Sun are to be found in the outer or highest regions of the solar photosphere.

I ought not to conclude without alluding to Mr. De La Rue's observations on the Solar Eclipse of 1860; but it must not be forgotten that *one* Daguerreotype picture was taken by Dr. Busch of the Solar Eclipse in 1851, and of the Solar Eclipse in 1860 *four* small pictures were also taken during the totality by Professor Monserrat under the direction of MM. Aguilar and Secchi at Desierto de las Palmas, in Spain.

Mr. De La Rue, during the progress of the same eclipse, took many large and exquisitely defined pictures, and secured two during the totality. I have no need to enter into details, as he has already described at several meetings of this Society, the numerical results that follow from the discussion, and the comparisons of the photographs which he took on that occasion. A paper, giving the result of his labours during the expedition to Rivabellosa, has been presented to the Royal Society, and is to be considered in March of this year.

Mr. De La Rue has invented an ingenious micrometer, lately exhibited at one of our Meetings, by means of which he fully confirms the hypothesis, that the coloured protuberances belong to the Sun, and renders it almost certain that the commonly received diameters both of the Sun and Moon require a correction.

More recently still, photographic pictures of the Sun have been obtained by Mr. De La Rue, not only exhibiting its well-known mottled appearance, but showing traces of Mr. Nasmyth's "willow leaves," and by the aid of stereoscopic pictures rendering it certain that the faculæ are elevations in the Sun's photosphere.

I need not enlarge on the wonderful discoveries which have been made and the astonishing results that have been obtained by Newton and his successors in this, the most fertile and exact of all the applied mathematical sciences. Neither would it become me, an humble but zealous worshipper of science, to hazard conjectures as to the *future progress of Astronomy*. And yet I cannot refrain from expressing my belief that the success already achieved by our friend warrants us in entertaining the hope that before long he will be able, with the aid of stereoscopic pictures, to exhibit to us the rose-coloured prominences depicted on the sensitive plates as plainly as the faculæ have already been photographed. The depths and the successive strata of those strange interlacing outliers within

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On the Perturbations of Uranus and the Mass of Neptune.
By Truman Henry Safford, Assistant at the Observatory
of Harvard College.

In the determination of the mean distance of the satellite of *Neptune*, and the consequent evaluation of that planet's mass, the faintness of the satellite has proved a great difficulty; so that different observers have differed systematically *inter se*, although each one is quite consistent with himself.

For instance, the mass of *Neptune*, from O. Struve's observations of the satellite, comes out $M = \frac{1}{14491} \pm 0.02431 M$, while Prof. G. P. Bond has deduced $M = \frac{1}{19400}$ from his father's and his own observations.

The perturbations of *Uranus*, by means of which *Neptune* was originally discovered, are, of course, adequate to determine its mass; and it would naturally be expected that the probable error of such a result would be much less than the difference between the numbers cited above.

Prof. Peirce, employing, I believe, the same observations as Leverrier did in his "*Recherches sur les Mouvements de la Planète Herschel (dite Uranus)*," has deduced (*Ast. Nach.*, No. 637) the result that, in general, a mass of *Neptune* nearly $\frac{1}{20000}$ will represent the motions of *Uranus* considerably nearer than a value more closely approaching to Struve's.

I was led to take up this question partly because it had been, some years ago, made the subject of a prize question by the Haarlem Society of Sciences (which, so far as I know, was not answered within the specified time), and partly because Struve's mass of *Neptune* seems to have been adopted by some high authorities; by Leverrier as, at least, a provisional value.

The perturbations of *Uranus* produced by *Neptune*, assuming $\frac{1}{19400}$ as the disturbing mass, were computed by the method of mechanical quadratures. These were then added to the perturbations of heliocentric longitude derived from Leverrier's theory, and the theory thus computed (so far as heliocentric longitude is concerned) was compared, for one date in each year, with the results from Bouvard's Tables contained in the *Greenwich Planetary Reductions*, and with the *Nautical Almanac* since 1836 inclusive, to 1858.

Errors of these latter theories in heliocentric longitude were obtained from the *Greenwich Planetary Reductions*, and the *Results of the Greenwich Observations*, 1836-1858; and thus the errors in heliocentric longitude of the present provisional theory were obtained.

It is proper to mention here, that Bradley's observation of 1753 was omitted here, as it seemed desirable to found the result on modern observations, using the ancient ones as a confirmation; also that where the error of radius vector in Bouvard's Tables was found sensible, observations in the neighbourhood of opposition were used.

The Paris observations (1801 to 1819), the Greenwich (1831 to 1835), and the Königsberg observations (1814 to 1846), were also used; the first series, as reduced by Leverrier, in the *Annales de l'Observatoire Impériale*, and the remainder after Flemming's (*Ast. Nach.* No. 755 *et seq.*), and Applebaum's (*Königsberg Observations*, vol. xxxii. p. 210 *et seq.*) reductions. It is known that the observations at these Observatories were made chiefly near opposition; and, indeed, Flemming has computed (with a few mistakes) the opposition as it is derived from observations made near it for a good many years.

Of course, every effort has been made to put all these reductions in the state in which they would have been if uniform star-places and other elements had been used in making them.

The results were found to indicate with some degree of probability, by a mere inspection, that the disturbing mass would need but little change. In fact, a preliminary solution of a set of twenty-six equations obtained by equating the residual errors of this first theory (taking the means of three years together) to functions of unknown variations of the elements of *Uranus* alone, represented these equating with final remainders of less than 4" in every case.

It seemed expedient, however, to introduce a variation of *Neptune's* mass as an unknown quantity; and after another preliminary solution, whose object was to obtain means for combining (as before) the observations of three years together, the weights were assigned to different series of observation, according to a somewhat arbitrary distribution. A final solu-

tion then gave the mass of *Neptune* $M = \frac{1}{20039}$ with a probable error in the denominator ± 295 .

The increase of *Neptune's* mass to $\frac{1}{14491}$ would have the effect of nearly quadrupling the mean error of observation; and would, in fact, leave intolerable discrepancies in several places.

An investigation now made into the geocentric longitudes derived from observations made before *Uranus* was actually recognised as a planet, gave eminently satisfactory results. The following is the comparison, with the observations used by Leverrier, p. 138 of his *Recherches*, "to form the first twelve equations, which are all ancient:"—

Year.	No. Obs.	Observer.	C—O.
1690	1	Flamsteed	— 5 ^o 0
1712	1	"	+ 18 ^o 1
1715	2	"	+ 5 ^o 9
"	1	"	+ 0 ^o 8
1750	1	Lemonnier	+ 4 ^o 0
"	1	"	— 1 ^o 6
1753	1	Bradley	+ 0 ^o 2
1756	1	Mayer	+ 0 ^o 9
1764	1	Lemonnier	— 0 ^o 4
1768	2	"	— 2 ^o 3
1769	6	"	— 5 ^o 3
1771	1	"	+ 5 ^o 0

Flamsteed's observation made in 1712 is uncertain, on account of the rate of the clock. It is isolated about 2½ hours from the comparison stars; and, during an interval of twenty or more days, for which there are only one night's observations, the clock was often very irregular.

Grouping the observations, as Leverrier has done (p. 239 of the Memoir above cited), we shall have as residual errors,—

	Error.	Leverrier's Limit.
1690	— 5	25
1712-15	+ 8	15
1750	+ 1 ^o 2	15
1753-56	+ 0 ^o 55	10
1768-69	— 4 ^o 55	10

All these observations are, therefore, represented much within the limits given by Leverrier, p. 240 of his *Recherches*.

On the Proper Motion of Sirius in Declination. By Truman Henry Safford, Assistant at the Observatory of Harvard College.

It is well known that *Sirius* exhibits irregularities of proper motion, both in Right Ascension and Declination. Bessel (*Ast. Nach.* Nos. 514-16), and Dr. C. A. F. Peters, in a Memoir, "Ueber die eigene Bewegung der *Sirius* (Habilitationsschrift), Königsberg, 1851," also republished in vol. xxxii. of the *Astronomische Nachrichten*, have investigated the variations of proper motion in Right Ascension. The hypothesis which these distinguished astronomers have adopted is, that the motions are performed around some centre of gravity, which is not at *Sirius* itself. This involves the idea of a dark body of considerable mass, whose attraction is exerted to draw *Sirius* from its hypothetical motion in a straight line. Dr. Peters does not, as I understand, insist that the dark body is of greater mass than *Sirius* itself; so that it may (possibly) be of planetary character.

The object of the present discussion is merely to show the character of the irregularities in Declination, and to examine whether they are reconcilable with the results derived from the Right Ascensions. The quantity which I have used in this investigation is the deviation of *Sirius* in Declination from the *Tabulæ Regiomontanæ*, less mean of the corresponding deviation for the four stars *Spica*, α^1 *Libra*, *Antares*, and α^1 *Capricorni*. These have the advantage over absolute declinations, that there is thus a possibility of avoiding a portion of the systematic errors to which most astronomical determinations are exposed. The mean of the Declinations of the four comparison stars is very nearly that of *Sirius*.

Bessel's Declinations are (it is well known) more than a second further south than other determinations, at a South Declination equal to 16° ; and in a matter of such delicacy it becomes necessary to scrutinise the observations quite closely.

Without a new reduction of Piazzi's and Pond's observations, it would be difficult to use them as fully authentic. The chief cause of disturbance seems to be the fact that Piazzi and Pond both used Bradley's factor for the thermometric variation of the refraction; and this value is largely erroneous. If *Sirius* is observed at a mean temperature different from that at which the four stars above mentioned are observed, an error is thus introduced. The refraction being large, it becomes of too great influence.

The effect (probably) of this error in the factor of the thermometric correction may be seen on comparing Olufsen's reduction of Pond's observations of 1822 with Pond's own. As α^1 *Capricorni* is not contained in Pond's reduction, we will (at

this period) omit it in considering Olufsen's. We find that by Pond's own reduction of his observations of 1822, *Sirius* is $1''.68$ further north than the *Tabulæ Regiomontanæ* make it; that *Spica*, α *Libræ*, and *Antares*, are (in the mean) $4''.55$, and, therefore, that *Sirius* is $2''.87$ too far south, as compared with these three stars. But, by employing Olufsen's reduction, *Sirius* is shown to be $0''.33$ too far north, and the three other stars in the mean $0''.95$; so that *Sirius*, as compared with these three, is $0''.62$ too far south.

The comparisons here given have been taken from Bessel's table (*Ast. Nach.* No. 73, p. 7).

The numbers which have been used are as follows, nearly :

		δ .
Bradley	1755	-0.7
Piazzi	1805	(-0.5)
Pond	1813	$(+0.6)$
Bessel	1820	-0.4
Pond	1822 (Olufsen)	-1.5
Struve	1824	-1.6
Pond	1826	(-2.1)
Argelander	1830	-1.0
Taylor*	1832	-1.7
Pond	1833	(-2.6)
Henderson*	1833	-1.5
Airy	1834	-2.4
Maclear*	"	-1.7
Henderson	1837	-0.8
Airy	1838	-0.4
Busch	"	-0.4
Bessel	1843	$+1.1$
Airy	1844	$+1.9$
"	1850	$+2.1$
Moesta*	1855	$+0.8$
Airy	1856	$+1.5$

* From observations near and south of the equator.

It may seem singular that the position of the *Fundamenta* for 1755, and Bessel's for 1820, should seem to differ at all from the *Tabulæ Regiomontanæ*, when the latter were calculated from the former. The numbers given above, for those Catalogues, are merely the corrections necessary, on account of the alteration in mutation, rendered necessary by more modern observations. Corrections have been applied also to Olufsen's reduction of Pond ($-0''.26$), to Argelander ($+0''.40$), and to Busch ($-0''.39$); these being the excess of the correction

taken from Table IV. on p. xxvi. of Struve's *Positiones Medie* for *Sirius* over the similar correction for the four stars compared.

Our table includes, then, the deviation from the *Tabula Regiomontana* of the Declination of *Sirius*, as observed by different observers, with (in general) different instruments, less the mean of the similar corrections for *Spica*, α *Libra*, *Antares*, and α *Capricorni*; corrected in the cases above specified for error of mutation.

On referring to Dr. Peters' memoir, we shall at once find that, if his hypothesis be adopted, the numbers given above will be represented by the formula

$$q' = b' + f' + c' (t - 1800) + g' \cos u + h' \sin u,$$

where b' denotes the correction of the Declination for 1800 of the centre of gravity of the system, c' the correction of Annual Proper Motion; each of these quantities to be applied to the *Tabula Regiomontana* values for *Sirius* itself, to get declinations in general accordance with Bessel's other declinations; g' , h' , being constants depending on the elements of the orbit of *Sirius* around the centre of gravity, and $f' = -g'e$, where e is the excentricity; u being also the excentric anomaly of *Sirius* in its orbit.

If, then, we adopt Peters' Elements V.,

Passage of the Lower Apse 1791'431

Mean Yearly Motion $7^{\circ}.1865$

Excentricity (e) 0.7994

we shall have

$$u - e \sin u = 7^{\circ}.1865 (t - 1791'431),$$

t being the date in years, and the predicted values of $\sin u \cos u$ can be easily computed. But, in the first place, it must be seen whether any hypothesis of uniform motion will represent the observations, excluding Bradley's of about 1755. It is found that a correction $-4''.18 + 10''.30 \left(\frac{t-1800}{100} \right)$ will materially lessen the errors. This correction, however, requires that Bessel's Bradley's place for 1755 be erroneous by $8''.7$; and that this is impossible is shown by the near agreement of Lacaille's and Mayer's places for 1750 and 1756 with the *Tabula Regiomontana*.

But the actual formula deduced from the observations by the substitution of Peters' hypothesis is

$$-0''.56 + 0''.0202 (t - 1800) + 1''.47 \sin u + 0''.51 \cos u,$$

and this leaves, as residual errors,

		C—O.
Bradley		0.0
Piazzi	1805	(+0.8)
Pond	1813	(-0.6)
Bessel	1820	-0.6
Pond	1822 (Olufsen)	+0.3
Struve	1824	+0.4
Pond	1826	(+0.8)
Argelander	1830	-0.5
Taylor	1832	+0.2
Henderson	1833	0.0
Pond	1833	+1.1 (14 observations.)
Airy	1834	+1.0
Maclear	1834	+0.3
Henderson	1837	-0.4
Airy	1838	-0.5
Busch	1838	-0.4
Bessel	1843	+0.5
Airy	1844	0.0
„	1850	-0.4
Moesta	1855	+0.5
Airy	1856	-0.4

There can be hardly any doubt, then, that Bessel's and Peters' hypothesis does actually represent the observed Declinations of *Sirius*, although the evidence on which it has been previously urged depends entirely on the Right Ascensions.

It may be noticed that Calandrelli's statement, that the *Greenwich Twelve-Year Catalogue* for 1845 (1844) is materially in error, is at once refuted by the almost perfect agreement given above. The phenomena which *Sirius* presented about 1841, that being according to Peters (confirmed by the results above) the time of the passage of the lower apside, are sufficiently remarkable; rapid variations both in Right Ascension and Declination were then taking place.

Extract of a Letter from Mr. A. Auwers to the Rev. R. Main, dated Königsberg, 1862, February 21, on the Irregularity of the Proper Motion of Sirius, and on a Missing Nebula.

(Communicated by the Rev. R. Main.)

For some months I have been attempting to represent the observed Declinations of *Sirius* from 1755 to 1859, in which a

periodical change of proper motion is very conspicuous, by a formula grounded on the elements of Peters; and I found the correction q' of the declinations of the *Tabulæ Regiomontanæ*, relatively to β *Orionis* and α *Hydræ*, from thirty-one equations,

$$q' = + 0''.10 + 0''.0158 (t - 1800) + 1''.536 \sin \kappa - 0''.025 \cos \kappa,$$

where

$$\kappa = 0''.7994 \sin \kappa = 7''.1865 (t - 1791.431),$$

The values of q' from the *Greenwich Six-Year Catalogue*, and from the observations from 1854 to 1859, are

$$- 0''.14, + 2''.36, + 2''.51, + 2''.65;$$

the elements give for these epochs

$$- 0''.66, + 2''.14, + 2''.36, + 2''.03,$$

and therefore completely justify your defence of the Greenwich declinations against the objections of Calandrelli.

It has only very recently been known to me that Mr. Safford has made a similar investigation, using, however, different stars of comparison. If the corrections q' of the declinations of *Sirius* be deduced from the formula given above, and from that communicated in No. 28 of the *Astronomical Notices*, we obtain:—

According to Safford,

$$q' = - 1''.00 + 0''.0104 (t - 1800) + 1''.47 \sin \kappa + 0''.51 \cos \kappa$$

According to my calculation,

$$q' = - 0''.60 + 0''.0003 (t - 1800) + 1''.536 \sin \kappa - 0''.025 \cos \kappa.$$

a satisfactory agreement with reference to the materials employed. This in fact is not unexceptionable, the probable error of a determination of declination being, according to Safford, $\pm 0''.30$, and according to me, $\pm 0''.32$, while at the same time I have found for *Procyon* an orbit, which represents the observed places with the probable errors $\pm 0''.17$. The reason of the lesser agreement of the Declination of *Sirius* arises plainly from the circumstance that this star for European Observatories culminates at too low an altitude. For a new determination of the elements of its orbit from all the observed Right Ascensions and Declinations, which I contemplate undertaking, determinations of southern Observatories would be very desirable. Is it known to you whether the observations of the Cape of Good Hope since 1834 are reduced?

I observed several times in February and March, 1858, the interesting Nebula found by Hind in 1852, and observed by D'Arrest and Breen in 1855 and 1856, and finally missed by D'Arrest in October 1861. In 1858 I found it to be fainter than it ought to have been, according to the description of D'Arrest in 1855. At that time I saw it with a telescope of $4\frac{1}{2}$ inches aperture, but, in January and September 1861, I could not find it with the 6-inch heliometer, nor have I been able to find it after repeated searches during the last five months. The variability of the accompanying star I remarked in November 1861, as I found it to be of the 11-12 magnitude, while in 1858 it was of the 10th magnitude. At present it appears to be getting somewhat brighter, and is of the 11th magnitude.

Extract of a Letter from Mr. A. Auwers to the Rev. R. Main, dated Königsberg, 1862, March 21, on the Orbit of Procyon, and on the Positions of the Radcliffe Catalogue.

(Communicated by the Rev. R. Main.)

I am much obliged for your answer to my letter of the 21st of February. Learning from your letter that the results of my researches on variable Proper Motions may perhaps be interesting to you, I add to the formula for correcting the tabular Declinations of *Sirius*, given in my preceding letter, also the elements of the orbit of *Procyon*, derived from all available observations of Right Ascension and Declination, made between 1750 and 1860:—

Epoch of minimum in R.A. = T	1795.5676	Probable error	$\pm 0''.4457$
Time of revolution = U	39 ^h .972	" "	$\pm 0''.4043$
Mean yearly motion = κ	9 ^s .00634	" "	$\pm 0''.09110$
Radius of circle = r	1 ^h .0525	" "	$\pm 0''.0275$

There is not the least trace of ellipticity indicated by the observations. The corrections to be applied to the Right Ascension of Wolfers' *Tabulae Reductionum*, relative to the mean of the stars *Aldebaran*, *Rigel*, α *Orionis*, *Pollux*, α *Hydrae*, and *Regulus*, and to the Declination of the same tables, relative to α *Ceti*, α *Orionis*, α *Serpentis*, γ , α , β *Aquilae*, and α *Aquarii*, are the following:—

$$d\alpha = +0''.0033 - 0''.001192 (t-1830) - 0''.0705 \cos \kappa (t-T),$$

$$d\delta = +0''.201 + 0''.00931 (t-1830) + 1''.853 \sin \kappa (t-T).$$

The mass of the dark companion of *Procyon* is probably not less than three-quarters of the mass of the Sun.

Variations have also been supposed to take place in the proper motions of α *Virginis*, α *Hydræ*, and β *Orionis*; but in all these cases the results of my researches are entirely negative, showing with evidence that there exist no variations in the motions of these stars.

The reason of my again taking the liberty to write to you is a paper "On the Positions of the Radcliffe Catalogue," in No. 9 of vol. xxi. of the *Monthly Notices*. It has not been before now that I have learnt that Mr. Safford calls attention by this paper to a rather large discrepancy between a formula, given by me in No. 1300 of the *Astronomische Nachrichten*, for correcting the Declinations contained in the vol. i.-xiv. of the *Radcliffe Observations*, so as to make them agree with Wolfers' *Tabulæ Reductionum*, and the corrections to be applied to these Declinations according to the late Mr. Johnson's investigation in vol. xv.

The formula has been derived, as it is stated in the *Astronomische Nachrichten*, from Mädler's comparisons (*Dorpat Observations*, xiv.), and represents them very accurately between the Declinations 40° and 80° . But now the definitive Declinations of the Radcliffe Catalogue having been substituted to the provisionally adopted ones of the *Observations*, I have thought it advisable to undertake a direct comparison of the first with some other Catalogues, the relations of which to the *Tabulæ Reductionum* are accurately known.

There occur 231 stars of the Radcliffe Catalogue in Argelander's Abo Catalogue reduced to 1845, and corrected for the difference between the constants of Nutation adopted in the construction of the Catalogue and the computation of the Proper Motions and the true value $= 9''.223$; the correction to be applied to the Declinations being $+ 0''.244 \sin(R.A. - 0^h 36^m)$, and to the Proper Motions $0''.0081 \sin(R.A. + 0^h 55^m)$. Argelander's Declinations differ from Johnson's (corrected, where necessary, according to the introduction of the Catalogue) by the following quantities, A—R, to which I have also added the differences W—A between the *Tabulæ Reductionum* and the Abo Catalogue, reduced to the year 1845, and the differences W—R, resulting from the addition of the numbers A—R and W—A.*

Decl.	A—R.	Stars Comp.	W—A.	W—R.
$-16^\circ 6'$	$+1^\circ 45' \pm 0' 15$	17	$-0' 72$	$+0' 73$
$-4^\circ 9'$	$+1^\circ 10' \pm 0' 19$	11	$-0' 63$	$+0' 47$
$+4^\circ 9'$	$+0^\circ 35' \pm 0' 13$	24	$-0' 53$	$-0' 18$
$+14^\circ 9'$	$+0^\circ 73' \pm 0' 18$	12	$-0' 41$	$+0' 32$

* Four stars presenting large differences have been excluded in taking the means.

Decl.	A - R.	Stars Comp.	W - A.	W - R.
+ 25° 9'	- 0° 41' ± 0° 21'	9	- 0° 25'	- 0° 66'
+ 35° 9'	- 0° 50' ± 0° 24'	7	- 0° 09'	- 0° 59'
+ 41° 7'	- 0° 12' ± 0° 10'	38	- 0° 01'	- 0° 13'
+ 48° 8'	+ 0° 12' ± 0° 11'	31	+ 0° 10'	+ 0° 22'
+ 53° 3'	+ 0° 53' ± 0° 12'	27	+ 0° 18'	+ 0° 71'
+ 62° 5'	+ 0° 45' ± 0° 14'	19	+ 0° 26'	+ 0° 71'
+ 69° 8'	+ 0° 67' ± 0° 15'	17	+ 0° 27'	+ 0° 94'
+ 76° 7'	+ 0° 92' ± 0° 22'	8	+ 0° 24'	+ 1° 16'
+ 84° 1'	+ 0° 99' ± 0° 22'	7	+ 0° 15'	+ 1° 14'

In a similar way I have found by 408 stars common to the Radcliffe Catalogue and Struve's *Positiones Medie* (including 93 already made use of in the preceding investigation),

Decl.	S - R.	Stars Comp.	W - S.	W - R.
- 15° 4'	+ 1° 81' ± 0° 24'	10	- 0° 82'	+ 0° 99'
+ 2° 0'	+ 0° 79' ± 0° 16'	19	- 0° 83'	- 0° 04'
+ 16° 2'	+ 0° 52' ± 0° 17'	20	- 0° 39'	+ 0° 13'
+ 30° 6'	- 0° 49' ± 0° 18'	18	- 0° 23'	- 0° 72'
+ 41° 1'	+ 0° 08' ± 0° 09'	70	- 0° 25'	- 0° 17'
+ 48° 6'	+ 0° 29' ± 0° 10'	53	- 0° 21'	+ 0° 08'
+ 55° 1'	+ 0° 51' ± 0° 08'	80	- 0° 09'	+ 0° 42'
+ 62° 4'	+ 0° 48' ± 0° 10'	56	+ 0° 11'	+ 0° 59'
+ 69° 3'	+ 0° 77' ± 0° 12'	37	+ 0° 18'	+ 0° 95'
+ 76° 6'	+ 0° 53' ± 0° 15'	25	+ 0° 14'	+ 0° 67'
+ 83° 7'	+ 0° 89' ± 0° 17'	20	+ 0° 02'	+ 0° 91'

The mean of the two nearly agreeing systems of values W - R becomes, for the circumpolar stars,

Decl.	W - R.	Stars.	Formula.	C - O.
41° 4'	- 0° 15'	108	- 0° 16'	- 0° 01'
48° 7'	+ 0° 13'	84	+ 0° 16'	+ 0° 03'
55° 2'	+ 0° 49'	107	+ 0° 41'	- 0° 08'
62° 4'	+ 0° 62'	75	+ 0° 16'	+ 0° 04'
69° 5'	+ 0° 95'	54	+ 0° 84'	- 0° 11'
76° 6'	+ 0° 79'	33	+ 0° 95'	+ 0° 16'
83° 8'	+ 0° 97'	27	+ 1° 02'	+ 0° 05'

Assuming the Weights of these numbers nearly proportional to the numbers of the stars compared, I have derived from them the following formula:—

$$W - R = - 2''.53 + 3''.59 \sin \lambda.$$

The column headed C—O contains the small remaining differences between this formula and the observed values. Tabulating the values of the formula with changed sign, we receive the following

Corrections of the N.P.D. of the Radcliffe Catalogue.

N.P.D.	Observ. vol. I.—xiv.		
		Johnson.	Formula.
0°	—1'06	+0'92	—0'14
5	—1'05	+0'97	—0'08
10	—1'01	+1'03	+0'02
15	—0'94	+1'10	+0'16
20	—0'84	+1'15	+0'33
25	—0'72	+1'23	+0'51
30	—0'58	+1'28	+0'70
35	—0'41	+1'34	+0'93
40	—0'22	+1'38	+1'16
45	—0'01	+1'43	+1'42
50	+0'22	+1'46	+1'68

In the vicinity of the pole, therefore, the provisionally adopted Declinations of the *Observations* agree far better with the *Tabulæ Reductionum* than the corrected Declinations of the Catalogue; but in Polar Distances greater than 25°, the opposite takes place.

The differences given by the Southern stars are somewhat irregular and less sure; the number of these occurring in the Catalogue being not at all great, I have thought it sufficient to join the values found between 54° and 106° N.P.D. to the circumpolar formula by drawing a simple curve, from which I have taken the following corrections of the N.P.D. of the Catalogue:—

N.P.D.		N.P.D.	
55°	+0'5	85°	—0'1
60	+0'6	90	—0'3
65	+0'6	95	—0'5
70	+0'5	100	—0'7
75	+0'3	105	—0'8
80	+0'1	110	—1'0

I may also mention that the differences between the Radcliffe Declinations and Argelander's in the hours 3—11 of R.A. are on the whole smaller (about 0''·5) than in the other hours; but in the comparisons with Struve, no such variation being shown, I have not had regard to it. The probable error of a difference A—R, by one star, is found from the circumpolar

stars to be $\pm 0''.622$, and that of a difference S—E is found to be $\pm 0''.743$. The probable error of a Declination of the Abo Catalogue being $\pm 0''.27$ and that of the reduction to 1845 being $\pm 0''.16$, the probable error of a Declination of the Radcliffe Catalogue becomes, from the comparisons with Argelander, $\pm 0''.54$.

Observatory, Königsberg, March 21, 1862.

Observations of Transit of Mercury, Solar Eclipse, and Occultation of Venus. By M. C. Bulard, Director of the Observatory of Algiers.

(Communicated by the Astronomer Royal.)

Transit of Mercury, 1861, November 11, observed at the Observatory of Algiers.

Egress, exterior* contact.

	^h	^m	^s	
	21	31	50.673	Algiers Mean Time,
or	21	28	28.073	Paris Mean Time.

Solar Eclipse of 1861, December 31.

The disturbed state of the country prevented M. Bulard from reaching the line of totality. The following observations were made at Ouargla:—

Latitude $31^{\circ}57'9''.0$ N.; Longitude (approximate) $21^{\circ}5'33$ E. of Greenwich.

	^h	^m	^s	
First Contact at	2	18	3.8	Ouargla Mean Time.

Last Contact at	4	41	16.1	„ „
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Occultation of Venus by the Moon, 1862, February 1, observed at Laghouat.

Latitude $33^{\circ}48'10''$ N.; Longitude (approximate) $11^{\circ}33'$ E. of Greenwich.

First Contact at	...	...	...	^h	^m	^s	
				6	55	10.558	(App ^y . Laghouat M. T.).

Disappearance of Left Horn of Venus	6	55	58.515	„
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Disappearance of Right Horn	...	6	56	0.011	„
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(as seen in an inverting telescope).

* There are the words of M. Bulard; but his diagram shows that it was internal contact. G. B. A.

Ephemeris of the Long Period Variable Stars for 1862. By N. R
Pogson, Director of the Madras Observatory.

The initials in the last column indicate respectively, Messrs. Argelander, Baxendell,
Krüger, Pogson, Schönfeld, and Winnecke.

Star.	Probable Mag.	Mean Place, 1861.		N.P.D.	Times of Maxima.			Authority.
		R. A. h m	°	°				
T Piscium	9.5	0 24 46	76 14	April 24, Sept. 14	...	...	S.	
α Cassiopeiae	2.0	0 32 35	34 14	March 20, June 7, Aug. 25, Nov. 12	...	...	A.	
S Piscium	9.0	1 10 15	81 49	Possibly in August.	Very uncertain	...	—	
R Piscium	7.5	1 23 25	87 50	Possibly in May.	Uncertain	...	—	
R Arietis	8.0	2 8 10	65 36	Jan. 15, July 17	...	...	B.	
α Ceti	2.0	2 12 17	93 37	July 3	...	...	A.	
R Tauri	8.0	4 20 38	80 9	May 7	...	...	W.	
S Tauri	10.0	4 21 32	80 22	March 11	...	...	W.	
R Orionis	9.0	4 51 22	82 5	June 19	...	...	W.	
α Orionis	1.0	5 47 36	82 37	January and July.	Uncertain	...	—	
R Geminorum	7.3	6 58 56	67 5	Jan. 25	...	...	P.	
R Can. Min.	8.0	7 1 0	79 46	April.	Uncertain	...	—	
S Can. Min.	7.5	7 25 7	81 23	July 23	...	...	W.	
S Geminorum	9.2	7 34 38	66 13	August 14	...	...	P.	
T Geminorum	8.9	7 40 54	65 55	May 13	...	...	P.	
U Geminorum	9.1	7 46 48	67 38	Jan. 21, April 28, Aug. 2, Nov. 7	...	...	P.	
R Cancrī	6.0	8 8 51	77 51	January 17	...	...	B.	
U Cancrī	9.0	8 27 45	70 37	July 3	...	...	W.	
S Hydræ	8.5	8 46 16	86 24	January 22, October 5	...	...	W.	
T Cancrī	12.0	8 48 40	69 37	At minimum, December 26	...	...	W.	
T Hydræ	6.5	8 48 51	98 37	February 22, December 11	...	...	W.	
R Leonis	5.0	9 40 2	77 55	Oct. 13. Minimum (10.0)	May 29	...	P.	
R Urs. Maj.	7.0	10 34 41	20 29	April 29. Minima (13.0)	Jan. 6, Nov. 4	...	P.	
T Leonis	9.0	11 3 36	83 47	February 9, August 28	...	...	W.	
R Comæ	8.0	11 57 4	70 26	October 1	...	...	W.	
R Virginis	6.5	12 31 24	82 14	Jan. 1, May 27, Oct. 19	...	...	A.	
S Urs. Maj.	7.5	12 37 48	28 8	{ April 10, Nov. 22. Minima (12) } { Jan. 2, Aug. 15	...	...	P.	
U Virginis	7.5	12 44 0	83 41	July 28	...	...	W.	
V Virginis	7.0	13 20 36	92 28	March 16, November 23	...	...	P.	
R Hydræ	4.0	13 22 4	112 33	Not until February 1863	...	...	B.	

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Star.	Probable Mag.	Mean Place, 1861.			Times of Maxima.			Authority.
		B.A.	N.P.D.					
S Virginis	6.0	13 25 42	96 28		May 21: Minimum (11.3)	Nov. 17		P.
R Boötis	8.0	14 31 1	62 39		February 16, September 29	...		W.
S Serpentis	8.0	15 15 7	75 11		March 5	...	...	A.
R Coronæ	6.2	15 42 49	61 25		About November.	Very irregular		B.
R Serpentis	6.5	15 44 15	74 26		August 29	...	...	A.
R Libræ	9.0	15 45 40	105 49		April. Uncertain	...	...	P.
R Herculis	8.5	15 59 56	71 15		Oct. 24	...	...	B. & W.
R Scorpïi	9.0	16 9 19	112 35		April 22.	Uncertain	...	P.
S Scorpïi	9.5	16 9 20	112 33		April 19.	Very irregular	...	—
S Ophiuchi	9.3	16 26 12	106 52		August 5	...	...	—
S Herculis	7.5	16 45 32	74 49		September 15	...	...	B.
R Ophiuchi	8.0	16 59 44	105 54		June 25	...	...	P.
α Herculis	3.0	17 8 16	75 27		{ Mar. 11, May 16, July 21, Sept. 26, }			A.
					{ Dec. 1	...	...	
T Herculis	7.9	18 3 48	59 0		March 16, August 23	...		K.
R Scuti	5.0	18 40 1	95 50		March 21, May 31, Aug. 11, Oct. 26			A.
13 Lyræ	4.3	18 51 4	46 14		{ March 18, May 3, June 18, Aug. 3, }			B.
					{ Sept. 18, Nov. 3	...	...	
R Aquilæ	6.5	18 59 38	81 59		May 13	...	...	A.
R Sagittarii	8.2	19 8 28	109 33		May 19	...	...	P.
S Sagittarii	10.5	19 11 14	109 16		December.	Very uncertain	...	P.
R Cygni	8.0	19 33 4	40 7		Nov. 14. Minimum (14.5)	June 12		P.
χ Cygni	5.0	19 45 11	57 27		June 10	...	...	A.
R Capricorni	9.5	20 3 28	104 41		September 25	...	...	W.
R Sagittæ	8.4	20 7 40	73 42		{ Minima (10.5) May 6, July 16, }			B.
					{ Sept. 25, Dec. 5	...	...	
S Delphini	8.2	20 36 38	73 25		May 4	...	...	B.
U Capricorni	10.5	20 40 22	105 18		April. Uncertain	...	...	P.
R Vulpeculæ	8.0	20 58 10	66 44		March 8, July 16, Nov. 23	...		W.
T Capricorni	9.0	21 14 13	105 45		July 26	...	...	S.
R Pegasi	8.5	22 59 37	80 14		April 28	...	...	A.
R Aquarii	7.0	23 37 15	106 3		June 28	...	...	—
R Cassiopeiæ	6.0	23 51 18	39 23		Nov. 15. Minimum (13)	May 30		P.

The preceding Ephemeris has been hastily prepared, chiefly from the elements of variation employed for the last two years.

Mr. Baxendell has as usual favoured me with the maxima of the stars bearing his initial. The minima of the Short Period Variable Stars shall follow by the next mail.

One star, S *Sagittarii*, was discovered at Dr. Lee's Observatory shortly before my departure from England, and has been re-observed here this year. Time forbids further details in this letter.

Madras Observatory, 1861, Dec. 28.

On the Stars R Vulpeculæ and U Geminorum, and on an Appearance in Venus. By G. Knott, Esq.

R *Vulpeculæ*. A few months ago I had the honour of submitting to the Astronomical Society a short paper on an unexpected *minimum* of this star; further observation enables me to report a *maximum*, mag. = 8.7, on or about the 31st December last. It will be seen that this result does not accord with the predictions of Mr. Pogson's valuable Ephemeris; by reference, however, to a paper by Dr. Winnecke, in No. 1224 of the *Astronomische Nachrichten*, it appears that the period is subject to considerable irregularity, for while two observed maxima in 1859 gave a period of 129 days, one of 147.35 days was found more satisfactorily to represent the earlier observations, including two by Piazzi in the beginning of the century. It would be premature on my part to say anything decidedly on this point, I will merely add that my own light-curve seems to favour the shorter period.

U *Geminorum*. This remarkable star was due at maximum on Jan. 21; my own observations show that the maximum actually occurred nineteen or twenty days earlier. On turning my Equatoreal to the spot on the evening of Jan. 3d, I found the star of the 9.4 mag., by the next evening it had fallen to 9.6, and on the 11th of the same month it shone as a star of the 11.2 mag. Bad weather and bright moonlight prevented further observation. Unfortunately the maximum was passed before my observations commenced, but we may probably assume the 1st or 2d of January as the date of its occurrence.

Readers of the *Monthly Notices* will remember an interesting paper by Mr. Pogson (*Monthly Notices*, vol. xx., p. 37) containing an account of a series of observations of this star by M. Goldschmidt in November 1859, from which, in combination with one of his own, he deduced a maximum on Nov. 12th, "full 27 days before the time indicated by computation." Starting from this date, and applying Mr. Pogson's period of 96.879 days, I find a maximum due on Dec. 25th, 1861, a result, which, compared with my own observations, seems to

show that, in the interval, the period has not been subject to any startling irregularity.

I take the opportunity of mentioning a recent observation of that curious phenomenon connected with the planet *Venus*, sometimes called the *phosphorescence of the dark side*. On the evening of Jan. 14th, my uncle, Mr. Berry of Liverpool, was examining the planet with a small but very perfect Gregorian reflector of 4 inches aperture, mag. power 160. The wind was high, but the atmosphere very clear, and in repeated intervals of quiet, when the cusps were sharply defined, the unilluminated part of the disk shone with a faint light similar in appearance to the *lumière cendrée* in the crescent Moon. In proof of the independence of the observation I may say, that, at the time, it had entirely escaped Mr. Berry's memory that the phenomenon had been remarked by previous observers.

Woodcroft, Cuckfield, March 10th, 1862.

Orbit of ξ Ursæ Majoris, determined from the Observations made between 1819.10 and 1860.08. By J. Breen, Esq.

Perihelion	1816.32
Period	63.14 years.
Excentricity	0.3929
Major semiaxis	2".454
	0'
Perihelion from node	132 53
Node	97 18
Inclination	52 16

Comparison of Observed and Calculated Places.

Date.	Angle of Position. [O—C] " "	Distance. [O—C] " "	Observer.
1819.10	+1 4	(+0.991)	Struve
1826.20	+2 28	+0.007	"
1831.08	-2 7	+0.157	Bessel
1835.41	+3 11	-0.112	Struve
1840.40	+1 36	+0.055	"
1843.48	-1 5	+0.235	Bessel
1848.32	-0 19	+0.028	J. Breen
1852.20	+1 18	-0.074	Fletcher
1857.40	+1 14	-0.081	"
1860.08	+0 58	-0.168	Lord Wrottesley.

Compared with the observations of Sir W. Herschel of 1781.97, and the single measurements of 1802.09 and 1804.08, the calculated angles of position are respectively $5^{\circ} 42'$, $5^{\circ} 17'$, and $6^{\circ} 21'$ in defect.

New Determination of the Longitude of the Sydney Observatory, by means of Thirty-three Moon-Culminations at Greenwich and Sydney, and Twenty-three at the Cape of Good Hope and Sydney. By W. R. Scott, Esq., Astronomer for New South Wales.

Assumed Longitude of Sydney Observatory $10^{\text{h}} 5^{\text{m}} 0^{\text{s}}$

Cape of Good Hope „ $1^{\text{h}} 13^{\text{m}} 55^{\text{s}}$

Greenwich Date.	Correction.	Greenwich Date.	Correction.
1860, Jan. 4	$-18^{\circ} 90'$	1860, July 3	$-10^{\circ} 13'$
9	$16^{\circ} 17'$	6	$2^{\circ} 90'$
Mar. 1	$16^{\circ} 56'$	30	$16^{\circ} 13'$
Apr. 2	$15^{\circ} 79'$	Oct. 5	$15^{\circ} 42'$
4	$12^{\circ} 39'$	Nov. 1	$13^{\circ} 71'$
6	$4^{\circ} 59'$	2	$8^{\circ} 36'$
7	$10^{\circ} 43'$	22	$14^{\circ} 26'$
9	$12^{\circ} 32'$	Dec. 22	$8^{\circ} 87'$
30	$17^{\circ} 65'$	1861, Jan. 24	$14^{\circ} 94'$
May 1	$15^{\circ} 56'$	28	$19^{\circ} 27'$
2	$15^{\circ} 36'$	Mar. 22	$6^{\circ} 56'$
3	$12^{\circ} 98'$	23	$13^{\circ} 02'$
4	$12^{\circ} 96'$	Apr. 24	$15^{\circ} 99'$
28	$17^{\circ} 01'$	May 17	$18^{\circ} 96'$
June 25	$13^{\circ} 34'$	22	$10^{\circ} 78'$
26	$14^{\circ} 33'$	July 15	$-14^{\circ} 48'$
30	$-7^{\circ} 60'$		

Cape of Good Hope.

Greenwich Date.	Correction.	Greenwich Date.	Correction.
1859, July 9	$-22^{\circ} 53'$	1859, Oct. 5	$-17^{\circ} 28'$
18	$9^{\circ} 40'$	8	$33^{\circ} 97'$
22	$8^{\circ} 81'$	12	$12^{\circ} 92'$
23	$9^{\circ} 14'$	13	$15^{\circ} 02'$
Aug. 11	$9^{\circ} 85'$	14	$14^{\circ} 40'$
12	$12^{\circ} 99'$	17	$14^{\circ} 28'$
13	$14^{\circ} 11'$	Nov. 3	$11^{\circ} 89'$
19	$18^{\circ} 15'$	4	$13^{\circ} 91'$
Sept. 9	$20^{\circ} 79'$	Dec. 5	$15^{\circ} 59'$
13	$19^{\circ} 22'$	8	$22^{\circ} 20'$
17	$9^{\circ} 78'$	14	$-14^{\circ} 37'$
19	$-17^{\circ} 53'$		

Mean of Corrections from Greenwich Observations $-13^{\circ} 26'$

„ „ from Cape of Good Hope „ $-15^{\circ} 75'$

Mean of all with Equal Weights ... $-14^{\circ} 21'$

Resulting Longitude of Sydney Observatory, $10^{\text{h}} 4^{\text{m}} 45^{\text{s}} \cdot 79$

**On Comet II., 1861, and on some other Comets.
By Dr. Mackay.**

(Communicated by Prof. C. P. Smyth.)

The Rev. Dr. Mackay, Missionary, Chinsurah, Bengal, has communicated through Prof. C. Piazzi Smyth, his (Dr. Mackay's) observations of the Comet II., or the Great Comet, 1861, and his computation of two sets of elements of the orbit, as follows,—

Ascending Node	279° 2'	278° 59' 30"
Inclination	85° 33'	85° 29' 32"
Perihelion dist.	·825	·8267
„ long.	249° 38'	249° 51'
„ passage	June 11 ^d 20 ^h	June 11 ^d 23 ^h

Motion direct.

The first was computed from his own observations of 1861, July 5, 10, 15, and was published in India on July 25th; the second one was computed in August, substituting a French observation of June 30th, printed in the *Journal des Debats*, for the first of his own observations.

The observations are remarkable instances of what may be done with “a sextant and an old ship's chronometer.” The Doctor writes, “My plan of observing was, to take every available evening a series of the Comet's distances from *Vega* and *Arcturus*, as near as possible to a mean of 9^h 5^m 33^s, Chinsurah Mean Time (3^h 12^m G.M.T.), and from these to compute the Comet's Right Ascension and Declination. With the found Right Ascension and Declination I computed its distance from a third star, *Ursæ Majoris*, which I also measured; and it was only when the computed and observed distances agreed, or slightly differed, (say 1') that I considered the night's work good.

“In October 1858, with the same sextant, but with better eyesight and longer intervals (6th, 18th, and 30th), I found the elements of the Comet of 1858,

Perihelion long.	37° 4'
„ dist.	·5753
„ passage	Sept. 29 ^d 18 ^h 21 ^m
Long. ascending Node	165° 15'
Inclination	63° 39'

Motion retrograde.

"These were published in the *Friend of India*, about a month before receiving the European determination, thus,

Perihelion long.	36° 13'
" dist.	579
" passage	Sept. 29 ^d 23 ^b
Longitude of Node	165° 19'
Inclination	63° 2'

Motion retrograde."

The following is the Doctor's printed local communication, published in the *Friend of India*, July 25, 1861, which, amongst other interesting particulars, contains his identification of the Comet with Comet I., 1781, computed by Mechain.

"With very considerable labour, by three reduced sextant observations of July 5th, 10th, and 15th, I have computed the following elements for the Comet. They can be considered only as approximate, as my sight is failing, and the intervals rather shorter than I could wish:—

Perihelion long.	249° 38'
" dist.	825
" passage	June 11 ^d 20 ^h 7
Long. ascending Node	99° 1'
Inclination	85° 33'

Motion direct.

"This differs considerably from Hind's May elements, as given in my former letter; but with an orbit almost perpendicular to the ecliptic, such differences are to be expected.

"From these elements I find that the Comet on the evening of July 5th was only eleven millions of miles from the Earth. Probably (for I have not calculated it) it was not much more than five millions, about the beginning of the month. This will account satisfactorily for its immense tail, and great velocity. I should be very thankful for any observations before the 5th and after the 15th. A week or two more will bring the determination from Europe of what the elements really are.

"Hind gives a group of four comets, with large inclinations, direct motions, and perihelion distances varying from .7 to .8, .9, and 1, for which periods have been computed of about 75 years. Another will now be added to the group; for I have no doubt that this comet is identical with the 1st of 1781, of which the elements were found by Mechain.

" They are as follows :

Perihelion long.	239°	Hind has 243
" dist.	755	
" passage	July 7 ^d	
Ascending Node	83°	
Inclination	81°	
Motion direct.		

If so, a comet with a known period of 80 years will take rank with Halley's. If they could be found, it would be interesting to recompute Mechain's calculations.

" On looking through Hind's list, I find a Comet in 1797 not very unlike, and another in 68 B.C., which I feel strongly disposed to identify with our Comet. From the obscure notices of the period in the Chinese annals, it appears to have had a perihelion distance of 8, and an inclination of 70°. Adding 68 to 1861, we have 1929, a near enough multiple of 80, when it is considered how much the cometary periods vary.

" No doubt all this has been discovered, and much more satisfactorily, in Europe; but it is new at least in this country.

" W. S. M."

" *Chinsurah*, 19th July, 1861.

" My observations were,—

		R. A.	N. Decl.
	^h ^m	[°] ['] ["]	[°] ['] ["]
July 5	3 12	172 31 30	66 40 20
10	3 12	206 10 15	59 41 17
15	3 12	215 41 0	54 50 32

The time is Greenwich mean time."

Extract of a Letter from Mr. Lassell.

(Communicated by Prof. De Morgan.)

" The principal work, however, I have hitherto done is the perfectly successful erection of the four-foot Equatoreal, on a most favourable site near Fort Tigné, on the north side of the Quarantine Harbour in this island. It differs a little from the lithographic drawing in the possession of the Society, as it is now erected in the latitude for which it was constructed, and not, as in that sketch, with the polar axis inserted in an excavation, to allow of its temporary use in the latitude of Liver-

pool. It is, indeed, much more substantially erected, with a view to its permanent efficiency in this far more favourable climate, where I trust it will do all that can reasonably be expected from 48 inches of aperture. I am glad to say that I have had no accident whatever in the erection, nor in the transmission of the mirrors, that which is now in the tube, after the dissolution and removal of its coat of varnish, having come out as fine in lustre as if it had been polished only yesterday.

"I have hitherto only cursorily examined a few objects, some of the minor conveniences of the apparatus not being yet quite completed; but I see enough to convince me that I have now a much more powerful and efficient telescope than I have ever possessed before. We are now passing through the most unsettled portion of the year, and I have found this so-called winter less favourable for the use of a large telescope than the same portion of the year 1852; I can, therefore, scarcely tell what the telescope will do under the most favourable circumstances. In turning it, however, upon the Nebula in *Orion*, I see so much more of its wonderful constitution, that I feel very ill-satisfied with my former drawings, and must begin anew. I was, indeed, at first rather surprised, perhaps disappointed, not to see many more new stars; but, on reflection, I am inclined to think this may be satisfactorily accounted for by the great increase of brightness of the Nebula rendering the eye less sensible to very minute points of light. And this view is confirmed by observations of stars in the day-time with the transit instrument, which, I suppose from the greater light of the sky here, are scarcely so visible as in England.

"The fainter and interior satellites of *Uranus*, *Umbriel* and *Ariel*, though as much inferior in brightness to what have been called the bright satellites, as *Rhea*, or even *Dione*, among the satellites of *Saturn*, is to *Titan*, are conspicuous objects; and, with a magnifying power of 1060, not to be overlooked on any tolerable night. If *Uranus* has any other satellites than these, they must be very much smaller or fainter.

"The only indication of *Saturn's* ring at present visible is its shadow as a thin, hard, dark, rough line across or along the equator of the planet, which is now so full of sharp belts over almost all its surface, that it might be taken for a view of *Jupiter* with a smaller telescope. On the 25th instant all the satellites but *Japetus* were in the field of view at once; *Mimas* and *Enceladus* within a very few seconds, indeed, of the limb of the planet; the latter almost touching it. Another of the nearer satellites emerged from behind the preceding limb during observation.

"P. S.—It is, perhaps, scarce worth mentioning, and yet it struck me as either a fortunate coincidence or an evidence of care, that I have had no occasion to touch the adjustments of either Right Ascension or Polar Distance since the telescope was

first directed to a celestial object; and, without having made any observations expressly for the purpose, I have not been made aware of any obvious error, in turning the telescope upon such objects as I have examined.

"9 *Piazza Slierna, Malta, 28th January, 1862.*"

And, in a letter dated the 30th January, Mr. Lassell writes,—"The detention of the mail allows me to add a postscript to my letter of yesterday, to inform you of my having discovered, last night, a new star within the trapezium in the great Nebula of *Orion*. It is situated near *Theta*, the principal star; appears to be about a full magnitude less than that known as 'the sixth star;' and is about one sixteenth of its distance from *Theta*. Its angle of position from *Theta* is about 100° less than that of 'the sixth star;' and, consequently, points a little eastward of the star at the opposite angle of the trapezium. For verification I annex a diagram.



"I suspect that the position-angle of 'the sixth star' has considerably increased since 1852."

Results of Meridional Observations of Small Planets; Occultation of a Star by the Moon; and Phenomena of Jupiter's Satellites; observed at the Royal Observatory, Greenwich, during the months of January and February, 1862.

(Communicated by the Astronomer Royal.)

Metis (9).

Mean Solar Time of Observation.			R. A. from Observation.			N.P.D. from Observation.			
	h	m	s	h	m	s	°	'	"
1862, Jan. 16	13	25	54.4	9	10	46.25	64	58	1.11
22	12	56	31.4	9	4	57.79	64	17	28.31
24	12	46	36.6	9	2	54.52	64	4	35.41
25	12	41	37.8	9	1	51.44	63	58	19.81
27	12	31	39.3	8	59	44.39	63	46	12.19
28	12	26	39.7	8	58	40.53	63	40	17.65
Feb. 3	11	56	40.3	8	52	15.56	63	8	28.38
7	11	36	48.6	8	48	6.80	62	50	58.54
10	11	22	2.0	8	45	7.42	62	39	54.42

Eunomia (16).

Mean Solar Time of Observation.			R.A. from Observation.			N.P.D. from Observation.		
		^h ^m ^s	^h ^m ^s	^h ^m ^s	^h ^m ^s	^h ^m ^s	^h ^m ^s	^h ^m ^s
1862, Jan.	25	12 16 36.2	8	36	45.72	75	52	24.27
	27	12 6 36.0	8	34	36.92	75	53	2.04
Feb.	10	10 57 31.8	8	20	33.16	75	55	8.66
	18	10 19 32.5	8	14	0.05	75	56	19.34

Thalia (20).

Mean Solar Time of Observation.	R.A. from Observation.			N.P.D. from Observation.		
	h	m	s	h	m	s
1862, Feb. 18	12	53	43.6	10	48	36.56

Calypso (26).

Mean Solar Time of Observation.	R.A. from Observation.			N.P.D. from Observation.					
	h	m	s	h	m	s	°	'	''
1862, Feb. 10	12	42	14.8	10	5	33.35	77	55	8.14

All the observations of N.P.D. have been corrected for refraction and parallax.

The disappearance of *d Geminorum*, on 1862, Jan. 14, at the Moon's dark limb was observed by Mr. Carpenter to take place at 6^h 29^m 58^s.9 G.M.T. The star was extremely faint.

Phenomena of Jupiter's Satellites.

Day of Observation.	Satellite.	Phenomenon.	Mean Solar Time.	Observer.
1862.			h m s	
Jan. 24	IV	Occ. reapp. last cont.	14 35 0.4	C.
28	I	Eclipse, disapp.	12 52 48.0	E.
Feb. 18	IV	Egress, first cont.	11 12 36.9	S.
"	IV	" last cont.	11 17 17.2	S.
"	III	Occ. reapp. first cont.	11 53 45.2	S.
"	III	" last cont.	12 2 6.9	S.

Feb. 18, The image of the planet exceedingly tremulous, and sometimes faint from cloud.

The initials S., E., C., are respectively those of Mr. Stone, Mr. Ellis, and Mr. Criswick.

Occultation observed at Highbury. By T. W. Burr, Esq.

1862, January 4th. The star α *Aquarii* disappeared at the dark limb of the Moon, at $1^h 34^m 49^s.6$ local sidereal time, $= 6^h 38^m 47^s.1$, Greenwich mean time. This occultation was instantaneous, but there had been a disappearance and reappearance about a minute previously, of an abnormal character. The Moon's dark limb was visible, and approaching the star extinguished it at $1^h 33^m 12^s.6$ L.S.T. After watching some little while, to be sure of the fact, I verified my time and recorded the observation, but on returning to the telescope was surprised to see the star again visible close to the Moon's edge, and finally disappearing as above mentioned. This is the only occasion out of the many occultations I have witnessed when anything unusual has occurred, but the observation in this case may be relied on.

The ultimate reappearance was not seen, owing to a passing cloud.

The time was checked by transits of α *Andromedæ* and β *Ceti*, corrected by Mr. Epps' tables (*Mem. Ast. Soc.* vol. iv.). Telescope, focal length, 4 ft. 4 in. Aperture, $3\frac{1}{2}$ in. Power, 173. Longitude, 24° W.

March 10, 1862.

Solar Eclipse of 31st December, 1861, observed at Goree, and at St. Louis, Senegal, by Officers of the French Imperial Navy.

By authority of the Duke of Newcastle, Secretary of State for the Colonies, Mr. Hind communicated to the Society the original of the Report of these observations, taken by the direction of the Governor of the French colony of Senegal; Mr. Hind states that the observations are due to the warm interest evinced by Capt. Washington, the Hydrographer of the Admiralty, on the occasion: he having forwarded a few instructions drawn up by the Astronomer Royal to the Governor of the Gambia, with a request that he would procure from the authorities at Goree a report of the eclipse.

The observers at St. Louis were MM. Vallon, Ribel, and De Marteville; those at Goree, MM. Poulain and Dutailis. The eclipse commenced at St. Louis about $0^h 4^m$, and the last contact was observed at $2^h 57^m 36^s.1$. At Goree the Moon had entered about one-tenth of the diameter on the solar disk at $0^h 3^m 35^s$, and the eclipse terminated at $2^h 51^m 18^s$.* For

* The times throughout are mean solar time of St. Louis or of Goree, according to the place of observation.— Ed.

want of a telescope of sufficient power the red prominences were not observed at Goree. The following are extracts from the Report:—

“*Saint Louis*.—A $1^h 30^m 50^s$ pendant que le croissant du Soleil passe rapidement à l'occident de la Lune, une magnifique protubérance se détache du côté opposé à 12° environ au-dessus du diamètre horizontal du Soleil. D'abord voisine de la corne supérieure orientale, sa base en partie cachée par la Lune embrasse 5 ou 6 degrés du disque solaire; le sommet, éclairé d'un beau rose, se dessine franchement sur une portion de couronne d'aspect rayonnant, jetant quelques ombres très mobiles qui descendent du nord au sud comme le feraient les ailes rapides d'un moulin à vent. Ces rayons d'ombre convergent au centre du Soleil.

“Ce beau phénomène dure de $1^h 30^m 50^s$ à $1^h 34^m 44^s$, heure à laquelle la protubérance et tout jeu de lumière s'effacent derrière le disque de la Lune. Cette protubérance étant très voisine de la perpendiculaire à la corde du croissant solaire, son immersion a été suivie avec soin. La base à d'abord disparu, puis graduellement toutes ses parties, dans le tems du mouvement de l'éclipse; enfin le sommet, au moment où l'épaisseur du croissant était mesurée au cercle $1' 10''$.

“Il est évident que cette mesure correspond à peu près exactement à la hauteur du sommet de la protubérance sur le disque du Soleil, auquel elle est *sans nul doute* attachée, ces deux éléments étant situés aux extrémités d'un même diamètre.

“Nous croyons que la protubérance est l'effet d'un amas de nuages solaires; le telescope permettait d'en compter les dentelures au nombre de trois principales sur son versant supérieur. La partie inférieure moins étendue paraissait en surplomb sur le bord de la Lune. Le sommet, mieux éclairé que la base, dont la Lune masquait le lieu de jonction au disque solaire, atteint son maximum d'éclat, une minute avant son immersion.

“*Gorée*.—Faute de télescope, on ne peut que reconnaître le beau phénomène de la couronne qui environne les disques superposés au point de produire l'effet d'une éclipse annulaire.

“*Saint Louis*.—La portion de couronne visible à l'orient de la Lune embrassait un secteur de 60 à 70 degrés. D'un beau rose près des disques des astres, les rayons allaient s'affaiblissant dans la teinte sombre du ciel. Sa structure était à rayons, et elle a paru suivre l'immersion graduelle de la protubérance.

“La lumière de cette portion de couronne a été observée à éclat; effet produit par les ombres rapides que nous avons signalées plus haut.

“*Gorée*.—Vers $1^h 25^m$ on voit des franges noires se dessiner sur le mur de la terrasse d'observation: à $1^h 26^m$ l'éclipse paraît centrale; un cercle lumineux existe autour du disque lunaire; son épaisseur est de $\frac{1}{2}$ de doigt; des aigrettes lumineuses émanent de tous côtés; à droite et à gauche elles sont

parfaitement symétriques ; au-dessus, il y en a une plus longue et plus large ; au-dessous elles sont plus courtes.

“ Il règne dans les environs une obscurité qu'on peut comparer à la lueur d'un crépuscule dans les plus belles régions de l'Europe. *Vénus* et trois autres étoiles paraissent au firmament à $2^h 34^m 30^s$; la distance de *Vénus* au Soleil a été observée $46^{\circ} 30'$.

“ *Saint Louis*. — Trois groupes de taches ont paru dans le 2^e quartier du Soleil, deux autres plus petits à la partie inférieure du 4^e quartier.

“ Ces taches ont en général un noyau brun dont les bords sont tranchés sur l'enveloppe vaporiforme qui la circonscrit. Cette enveloppe, d'une teinte neutre affaiblie, a un contour bien accusé sur le disque du Soleil.

“ Nous affirmons que pendant la durée de l'observation aucune de ces taches n'a changé de position relative, de forme absolue, ni de teinte.

“ Doivent-elles leur existence au déchirement de la photosphère qui laisserait apercevoir le noyau central du Soleil, ou son enveloppe de nuages obscurs, suivant Arago ? Cette explication satisfait pleinement la vue. Sont-elles le résultat d'une accumulation de nuages solaires de même nature que les protubérances ? Cette dernière supposition fort ingénieuse ne nous paraît cependant pas soutenable, et n'explique ni la figure étrange des taches, ni leur immobilité pendant 3 heures, ni enfin la permanence des effets de l'éclairage de toutes leurs parties.

“ Le centre des taches principales renfermait des espaces lumineux disposés irrégulièrement. La Lune, dans son ascension, a successivement recouvert ces groupes ; ils devenaient d'autant plus visibles que son disque s'en approchait d'avantage. Aucune de ces taches en s'immergeant, ou en reparais-sant, n'a subi la moindre altération de forme. Les cornes du Soleil se sont effilées sans distorsion apparente.

“ Les baromètres au moment de la plus grande obscurité sont descendus de 763.5 à 762.5 .

“ Les thermomètres au Soleil de 34° centigrades à $23^{\circ} 6$.

“ Les thermomètres à l'ombre de $28^{\circ} 3$ centigrades à $23^{\circ} 5$.

“ L'arguille aimantée n'éprouve aucune oscillation.

“ Les deux hygromètres accusent 10 centièmes d'humidité en plus.

“ Enfin, la face du Soleil a paru très homogène, à part quelques groupes irréguliers de facules lumineuses qui environnent les deux petits groupes de taches inférieures.

“ *Gorée*. — Le thermomètre à l'ombre est descendu de $25^{\circ} 8$ à 20 degrés. La courbe de la chaleur paraît d'accord avec celle de la lumière.

“ Le baromètre a varié entre 762 et 763 .

“ Le psychromètre, formé de deux thermomètres, un sec et mouillé, donnait en centièmes, au moyen des tables, la



quantité d'humidité renfermée dans l'air. Il a accusé 12 centièmes d'augmentation.

"Le phénomène des franges noires a été observé un instant avant l'occultation; elles avaient, sur une surface verticale dirigée sensiblement de l'ouest à l'est, une direction de 45° par-dessus l'épaule gauche; leur largeur et leur espacement étaient à-peu-près égaux et mesuraient environ 10 centimètres. La nuance était une ombre claire qui a paru dégradée sur les bords.

"Avant et après l'occultation, les animaux domestiques et les plantes ont été influencés comme à l'approche de la nuit et au lever du jour.

"Il y avait à Gorée un raz de marée exceptionnel.

"*Saint Louis.*—*Vénus* a paru dans le S. E. au moment de la plus grande obscurité. Les édifices blanchis à la chaux paraissaient gris jaunâtres. Le rouge conservait sa couleur. La moindre épaisseur du croissant solaire a été mesurée $57''$ à $1^h 30^m 49^s$."

Sir Thomas Maclear has communicated Observations of the Right Ascensions and North Polar Distances of Comet I., 1861, made at the Royal Observatory, Cape of Good Hope, from 18th August to 6th September, 1861; and in a letter, dated 21st December, 1861, addressed to the Astronomer Royal, he writes:—

"Dr. Pape's ephemeris reached the Cape too late. By extending it from August 6th, its limit, the comet was readily found—then too faint, however, for precise work.

"I detected Encke's Comet on the 4th instant, but the light was too feeble for place, and a few days after the moonlight extinguished it altogether. It is now workable, and I hope for a good series of observations.

"It would be well to get up a rough working ephemeris of all the periodic comets several months beforehand, and to circulate them freely. By rough I mean with omission of the perturbation corrections."

The observations will probably be printed, along with those of Comet II., 1860, in the *Memoirs* of the Society.—Ed.

A paper "On Astronomical Refraction," by Mr. Andrew Yeates, was read at the Meeting.

Among the Presents to the Society, there were presented by Mr. H. G. Bohn of York Street, Covent Garden:—

Opusculum Johannis de Sacrobusto Sphericum. Lipsiæ, 4to. s.a.

Ditto. Liptczk, 4to. 1499; with additional matter in manuscript.

Flores Albumasaris, Ehrhardt Ratdolt. 4to. 1495. At the end there are about 22 pages of Astrological matter, beautifully written in a monastic or court hand.

Discovery of a Companion of Sirius.

In the *Ast. Nach.*, No. 1353, Prof. Bond communicates the discovery of a Companion of *Sirius*, made on the evening of Jan. 31 by Mr. Clark, with his new object-glass of 18½ inches aperture. Prof. Bond was able to observe it with the Refractor of 15 inches, at the Observatory of Harvard College, as follows:

1862, Feb. 10, Angle of Position	85° 15	± 1° 1
Distance	... 10"·37	± 0"·2

when the images were tranquil, the Companion was seen distinctly enough, but on account of the atmospheric disturbances these moments are quite rare.

The Companion was seen at Paris by M. Chacornac, the 20th March, with the telescope with silvered mirror of 80 centimeters, constructed according to the plans and under the direction of M. Foucault.

It appears from the *Cosmos* of 28th March, that Dr. Peters does not accept the identity of the Companion thus discovered with that which he had calculated.

Discovery and Elements of a New Minor Planet, (2).

In the *Ast. Nach.*, No. 1353, Prof. Bond communicates also the discovery of this new Minor Planet, under the following circumstances. Mr. Safford having had occasion to refer to the positions of *Maia* ☿, obtained by Dr. Peters at Hamilton

College, and published in Brünnow's *Astronomical Notices*, No. 20, was surprised to find that only three of the series, namely, the places for 1861, May 9, 11, and 12, could be reconciled with the Cambridge (U.S.) observations. A reference to Mr. Hall's Ephemeris of *Maia* (*Ast. Nach.*, No. 1315), showed that the Ephemeris represented the Cambridge observations of *Maia* from April 9 to May 27, nine in number, and also the first three of those of Dr. Peters, but that it did not represent the later observations of Dr. Peters. It was at once conjectured that in the interval between May 12 and May 29, when clouds and moonlight intervened to prevent a close following of *Maia*, which was only of the 13th mag., Dr. Peters had lost its trace, and on resuming his observations had fallen on a new Planet. Mr. Safford, after obtaining corrected positions of the comparison stars of Dr. Peters, obtained the following elements,—

$$\begin{array}{rcl}
 & 1861, \text{ May } 29^{\circ} 37' 5'' & \text{Washington M.T.} \\
 L & = 213^{\circ} 3' 24''.1 & \\
 \pi & = 329'' 22' 16''.5 & \left. \begin{array}{l} \\ \\ \end{array} \right\} \text{Mean Equinox 1861.0} \\
 \Omega & = 208^{\circ} 1' 28''.0 & \\
 i & = 5^{\circ} 23' 16''.2 & \\
 \phi & = 6^{\circ} 50' 26''.0 & \\
 \mu & = 1129'' \cdot 372 & \\
 \log a & = 0 \cdot 331446 &
 \end{array}$$

It is noticed that (79) has the least mean distance yet recognised among the Minor Planets.

RECENT PUBLICATION.

A Handbook of Descriptive and Practical Astronomy. By Geo. F. Chambers, F.R.G.S. 8vo. London, 1861.

The author remarks that his book is intended to occupy a middle position between purely elementary books on the one hand, and advanced treatises on the other hand; to be attractive to the general reader, useful to the amateur, and "handy" also as an occasional book of reference to the professional astronomer. Pains have been taken to incorporate the most recent discoveries in all branches of the science, and the Work appears to be very complete in its range of subjects; and in general to be fully entitled to take up the position claimed for it by the author. The chronological tables of Astronomers and of Discoveries in Book 9, and the tables of Eclipses, Comets, Star Catalogues, &c., contained in the Appendices, will probably be found useful for reference.

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MONTHLY NOTICES

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*On the Secular Acceleration of the Moon's Mean Motion.**

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The present Memoir exhibits a new method of taking account, in the Lunar Theory, of the Variation of the Excentricity of the Sun's Orbit. The approximation is carried to the same extent as in Prof. Adams' Memoir "On the Secular Variation of the Moon's Mean Motion" (*Phil. Trans.*, vol. cxliii. (1853), pp. 397-406); and I obtain results agreeing precisely with his, viz., besides his new periodic terms in the longitude and radius vector, I obtain in the longitude the secular term

$$\left(-\frac{3}{2}m^2 + \frac{3771}{64}m^4\right) \int (e'^2 - E'^2) n \, dt,$$

and in the quotient radius, or radius vector divided by the mean distance, the secular term

$$\left(\frac{3}{4}m^2 - \frac{1973}{64}m^4\right) (e'^2 - E'^2),$$

which is, in fact, as will be shown, included implicitly in the results given in Professor Adams' Memoir. In quoting the foregoing results, I have written $e'^2 - E'^2$ in the place of $(e' + f' t)^2 - e'^2 = 2 e' f' t$, which in the notation of the present Memoir it should have been; and I purposely refrain from here explaining the precise signification of the symbols: this is carefully done in the sequel. The method appears to me a very simple one in principle; and it possesses the advantage that it is not incorporated step by step with a lunar theory in which the

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in which

$$\epsilon' = \epsilon \text{qr} (\epsilon' + \delta \epsilon', g')$$

$$v' = n't + i' + [\text{elta} (\epsilon', g') - g']$$

I now change the notation by writing $\epsilon' + \delta \epsilon'$, $v' + \delta v'$, in the place of ϵ' , v' , respectively, using henceforward ϵ' , v' to denote

$$\epsilon' = \epsilon \text{qr} (\epsilon', g')$$

$$v' = n't + i' + [\text{elta} (\epsilon', g') - g'];$$

and I write also $\epsilon + \delta \epsilon$, $v + \delta v$, in the place of ϵ , v , using henceforward ϵ , v to denote the solutions of the equations obtained from the equations of motion by writing therein ϵ' , v' instead of the complete values $\epsilon' + \delta \epsilon'$, $v' + \delta v'$.

Suppose, in like manner, that the complete values of P , Q are denoted by $P + \delta P$, $Q + \delta Q$, where

$$\delta P = \frac{dP}{d\epsilon} \delta \epsilon + \frac{dP}{dv} \delta v + \frac{dP}{d\epsilon'} \delta \epsilon' + \frac{dP}{dv'} \delta v',$$

with a like value for δQ , the first powers of $\delta \epsilon$, δv , $\delta \epsilon'$, $\delta v'$ being alone attended to. Then, observing that the equations of motion are satisfied when $\delta \epsilon$, δv , $\delta \epsilon'$, $\delta v'$ are neglected, we have, it is clear,

$$\frac{d}{dt} \frac{d\delta \epsilon}{dt} - \delta \epsilon \left(\frac{dv}{dt} \right)^2 - 2\epsilon \frac{dv}{dt} \frac{d\delta v}{dt} - \frac{2n^2}{\epsilon^3} \delta \epsilon = m^2 n^2 \delta P,$$

$$\frac{d}{dt} \left(\epsilon^2 \frac{d\delta v}{dt} + 2\epsilon \delta \epsilon \frac{dv}{dt} \right) = m^2 n^2 \delta Q.$$

The second of these equations gives

$$\epsilon^2 \frac{d\delta v}{dt} + 2\epsilon \delta \epsilon \frac{dv}{dt} = m^2 n^2 (C + \int dQ dt),$$

where the constant of integration, C , is to be so determined that δv may not contain any term of the form kt (for any such term is taken to be included in the term $n't$ of $v + \delta v$). Multiplying the equation just obtained by $\frac{2}{\epsilon} \frac{dv}{dt}$, and adding it to the first equation, we have

$$\frac{d^2 \delta \epsilon}{dt^2} + \left\{ 3 \left(\frac{dv}{dt} \right)^2 - \frac{2n^2}{\epsilon^3} \right\} \delta \epsilon = m^2 n^2 \left(\delta P + \frac{2}{\epsilon} \frac{dv}{dt} (C + \int dQ dt) \right),$$

which, with the above-mentioned integral equation, are the

equations for the solution of the problem; but it will be convenient to write them under the slightly different form

$$\frac{d^2 \delta \epsilon}{dt^2} + n^2 \delta \epsilon = \left\{ n^2 + \frac{2n^2}{\epsilon^3} - 3 \left(\frac{dv}{dt} \right)^2 \right\} \delta \epsilon + m^2 n^2 \left\{ \delta P + \frac{2}{\epsilon} \frac{dv}{dt} \left(C + \int \delta Q dt \right) \right\},$$

$$\frac{d \delta v}{dt} = - \frac{2}{\epsilon} \frac{dv}{dt} \delta \epsilon + \frac{m^2 n^2}{\epsilon^3} \left(C + \int \delta Q dt \right).$$

In these equations C is determined, as above, by the condition that $\frac{d \delta v}{dt}$ may contain no constant term; the values of ϵ' , v' , $\delta \epsilon'$, $\delta v'$ are of course given by the theory of elliptic motion, and those of ϵ , v are given by the ordinary lunar theory, in which the excentricity of the solar orbit is treated as a constant; and then, $\delta \epsilon$, δv being obtained by integrating the equations, the radius vector and longitude of the Moon are $a(\epsilon + \delta \epsilon)$ and $v + \delta v$ respectively.

We have

$$P = \frac{\epsilon}{\epsilon'^3} \left(\frac{1}{2} + \frac{3}{2} \cos 2v - 2v' \right),$$

$$Q = \frac{\epsilon}{\epsilon'^3} \left(- \frac{3}{2} \sin 2v - 2v' \right).$$

Moreover, by the lunar theory, observing that Plana's α is or may be considered identical with the α of the present Memoir, and putting also

$$\tau = nt + t - (n't + t'),$$

we have

$$\begin{aligned} \frac{1}{\epsilon} &= 1 + \frac{1}{6} m^2 - \frac{3}{4} m^2 e'^2 \\ &\quad - \frac{3}{2} m^2 e' \cos g' \\ &\quad + m^2 - \frac{5}{2} m^2 e'^2 \quad ,, \quad 2\tau \\ &\quad + \frac{7}{2} m^2 e' \quad ,, \quad 2\tau - g' \\ &\quad - \frac{1}{2} m^2 e' \quad ,, \quad 2\tau + g' \\ &\quad - \frac{9}{4} m^2 e'^2 \quad ,, \quad 2g' \\ &\quad + \frac{17}{2} m^2 e'^3 \quad ,, \quad 2\tau - 2g' \\ &\quad 0 m^2 e'^3 \quad ,, \quad 2\tau + 2g'. \end{aligned}$$

$$v = nt + 1$$

$$\begin{aligned} & - 3 m e' + 0 m^2 e' \quad \sin g' \\ & + \frac{11}{8} m^2 - \frac{55}{16} m^2 e'^2 \quad ,, \quad 2 \tau \\ & + \frac{77}{16} m^2 e' \quad ,, \quad 2 \tau - g' \\ & - \frac{11}{16} m^2 e' \quad ,, \quad 2 \tau + g' \\ & - \frac{9}{4} m e'^2 + 0 m^2 e'^2 \quad ,, \quad 2 g' \\ & + \frac{187}{16} m^2 e'^2 \quad ,, \quad 2 \tau - 2 g' \\ & 0 m^2 e'^2 \quad ,, \quad 2 \tau + 2 g', \end{aligned}$$

where the series are carried as far as m^2 and e'^2 ; the terms in e'^2 are given, as I shall have occasion to refer to them, but they are not used in the investigation, and, omitting them, the values are

$$\begin{aligned} \frac{1}{\xi} &= 1 + \frac{1}{6} m^2 \\ & - \frac{3}{2} m^2 e' \cos g' \\ & + m^2 \quad ,, \quad 2 \tau \\ & + \frac{7}{2} m^2 e' \quad ,, \quad 2 \tau - g' \\ & - \frac{1}{2} m^2 e' \quad ,, \quad 2 \tau + g', \end{aligned}$$

$$v = nt + 1$$

$$\begin{aligned} & - 3 m e' \sin g' \\ & + \frac{11}{8} m^2 \quad ,, \quad 2 \tau \\ & + \frac{77}{16} m^2 e' \quad ,, \quad 2 \tau - g' \\ & - \frac{11}{8} m^2 e' \quad ,, \quad 2 \tau + g' \end{aligned}$$

$$(g' = c' m n t + \text{const.}, \quad 2 \tau = (2 - 2 m) n t + \text{const.})$$

For the co-ordinates of the Sun we have

$$\begin{aligned}\frac{1}{\zeta'} &= 1 \\ &+ e' \cos g' \\ &+ e'^2 \quad \text{,, } 2 g', \\ v' &= n' t + i' \\ &+ 2 e' \sin g' \\ &+ \frac{5}{4} e'^2 \quad \text{,, } 2 g',\end{aligned}$$

the series being carried as far as e'^2 ; but the terms in e'^2 are only used for the formation of $\delta \zeta'$, $\delta v'$; and, omitting them, we have

$$\begin{aligned}\frac{1}{\zeta'} &= 1 \\ &+ e' \cos g', \\ v' &= n' t + i' \\ &+ 2 e' \sin g' .\end{aligned}$$

If $e' + f' t$ is written for e' , then the value of $\delta e'$ is $= f' t$; but as only the terms multiplied by the simple power f' are attended to, we may for convenience write $\delta e' = t$, the factor f' being restored in the final results: we thus have

$$\begin{aligned}\delta \frac{1}{\zeta'} &= 1 \quad t \cos g' \\ &+ 2 e' \quad \text{,, } 2 g', \\ \delta v' &= 2 \quad t \sin g' \\ &+ \frac{5}{2} e' \quad \text{,, } 2 g',\end{aligned}$$

and we may add the equations

$$\begin{aligned}\frac{dv}{dt} &= \overbrace{1}^{n \times} \\ &- 3 m^2 e' \cos g' \\ &+ \frac{11}{4} m^2 \quad \text{,, } 2 \tau \\ &+ \frac{77}{8} m^2 e' \quad \text{,, } 2 \tau - g' \\ &- \frac{11}{8} m^2 e' \quad \text{,, } 2 \tau + g',\end{aligned}$$

$$\begin{aligned}
 \delta \frac{1}{\epsilon'^2} &= 3 \epsilon' t \\
 &+ 3 t \cos g' \\
 &+ \frac{9}{2} \epsilon' \quad ,, \quad 2 g', \\
 \delta \frac{v'}{\epsilon'^2} &= 2 t \sin g' \\
 &+ \frac{11}{2} \epsilon' \quad ,, \quad 2 g',
 \end{aligned}$$

which will be found useful.

II.

Proceeding now to the development of the solution, we have

$$\begin{aligned}
 \delta P &= \frac{1}{\epsilon'^2} \left(\frac{1}{2} + \frac{3}{2} \cos 2v - 2v' \right) \delta \epsilon \\
 &+ \frac{\epsilon}{\epsilon'^2} \left(-\frac{3}{2} \sin 2v - 2v' \right) \delta v \\
 &+ \epsilon \left[\left(\frac{1}{2} + \frac{3}{2} \cos 2v - 2v' \right) \delta \frac{1}{\epsilon'^2} + \left(3 \sin 2v - 2v' \right) \delta \frac{v'}{\epsilon'^2} \right],
 \end{aligned}$$

where the terms containing $\delta \epsilon$ and δv are (see Annex 1)

$ \begin{aligned} &\frac{1}{2} \\ &+ \frac{3}{2} \epsilon' \cos g' \\ &+ \frac{3}{2} \quad ,, \quad 2 \tau \\ &+ \frac{21}{4} \epsilon' \quad ,, \quad 2 \tau - g' \\ &- \frac{3}{4} \epsilon' \quad ,, \quad 2 \tau + g' \end{aligned} $	$\delta \epsilon$
$ \begin{aligned} &- 3 \sin 2 \tau \\ &- \frac{21}{2} \epsilon' \quad ,, \quad 2 \tau - g' \\ &+ \frac{3}{2} \epsilon' \quad ,, \quad 2 \tau + g' \end{aligned} $	$\delta v,$

and also

$$\begin{aligned} \delta Q = & \frac{e}{e'^3} (-3 \sin 2v - 2v') \delta e \\ & + \frac{e^3}{e'^3} (-3 \cos 2v - 2v') \delta v \\ & + e^3 \left[\left(-\frac{3}{2} \sin 2v - 2v' \right) \delta \frac{1}{e^3} + 3 \cos 2v - 2v' \right] \frac{\delta v'}{e'^3}, \end{aligned}$$

where the terms containing δe and δv are (see Annex 2)

$\begin{aligned} & -3 \sin 2\tau \\ & -\frac{21}{2} e' \quad ,, \quad 2\tau - g' \\ & +\frac{3}{2} e' \quad ,, \quad 2\tau + g' \end{aligned}$	δe
$\begin{aligned} & -3 \cos 2\tau \\ & -\frac{21}{2} e' \quad ,, \quad 2\tau - g' \\ & +\frac{3}{2} e' \quad ,, \quad 2\tau + g' \end{aligned}$	$\delta v,$

but the additional term $\frac{171}{4} m^2 e' \cos g'$ is ultimately added (see Annex 17) to the coefficient of δv .

Neglecting the terms in δe , δv , we have (see Annex 4)

$$\begin{aligned} \delta P = & \frac{3}{2} e' \quad t \\ & + \frac{3}{2} \quad t \cos g' \\ & - \frac{15}{2} e' \quad ,, \quad 2\tau \\ & + \frac{21}{4} \quad ,, \quad 2\tau - g' \\ & - \frac{3}{4} \quad ,, \quad 2\tau + g' \\ & + \frac{9}{2} e' \quad ,, \quad 2g' \\ & + \frac{51}{2} e' \quad ,, \quad 2\tau - 2g', \end{aligned}$$

and similarly (see Annex 5),

$$\begin{aligned}\delta Q &= \frac{15}{2} e' t \sin 2\tau \\ &\quad - \frac{21}{4} \quad \text{,, } 2\tau - g' \\ &\quad + \frac{3}{4} \quad \text{,, } 2\tau + g' \\ &\quad - \frac{51}{2} e' \quad \text{,, } 2\tau - 2g' .\end{aligned}$$

But in the foregoing expression of δP the terms belonging to the arguments g' , $2g'$ give in $\delta \epsilon$, terms which rise by integration in δv ; and in forming the expressions for δP , δQ , it is proper to take account of these terms. Attending only to the terms in question, we have

$$\begin{aligned}\frac{d^2 \delta \epsilon}{dt^2} + n^2 \delta \epsilon - m^2 n^2 \delta P &= \overbrace{\frac{3}{2} m^2 t \cos g'}^{n^2 \times} \\ &\quad + \frac{9}{2} m^2 e' \quad \text{,, } 2g' .\end{aligned}$$

Now in general, if

$$\frac{d^2 \delta \epsilon}{dt^2} + n^2 \delta \epsilon = n^2 t \cos n\alpha t ,$$

then

$$\delta \epsilon = \frac{2\alpha}{(1-\alpha^2)^2} \sin \alpha t + \frac{1}{1-\alpha^2} t \cos \alpha t ;$$

and hence the foregoing equation gives in $\delta \epsilon$ the terms

$$\begin{aligned}3 m^3 \sin g' &\quad + \frac{3}{2} t \cos g' \\ + 18 m^2 e' \quad \text{,, } 2g' &\quad + \frac{9}{2} m^2 e' \quad \text{,, } 2g' ;\end{aligned}$$

or, neglecting the terms which contain m^3 , the terms of $\delta \epsilon$ are

$$\begin{aligned}\frac{3}{2} m^2 t \cos g' \\ + \frac{9}{2} m^2 e' \quad \text{,, } 2g' .\end{aligned}$$

Substituting these terms in

$$\frac{d\delta v}{dt} = -2\pi\delta e,$$

we have

$$\frac{d\delta v}{dt} = \overbrace{-3m^2 t \cos g'}^{\pi^{-1} \times} \\ -9m^2 e' \quad ,, \quad 2g';$$

and since, in general,

$$\int t \cos \pi \alpha t dt = \frac{1}{\pi^2 \alpha^2} \cos \pi \alpha t + \frac{1}{\pi \alpha} t \sin \pi \alpha t,$$

we obtain in δv the terms

$$\overbrace{-3 \cos g'}^{\pi^{-1} \times} + \overbrace{-3m t \sin g'} \\ -\frac{9}{4} e' \quad ,, \quad 2g' \quad -\frac{9}{2} m e' \quad ,, \quad 2g',$$

or for the present purpose the terms

$$\overbrace{-3 \cos g'}^{\pi^{-1} \times} \\ -\frac{9}{4} e' \quad ,, \quad 2g';$$

and these give in δP the additional terms (see Annex 6)

$$\overbrace{\frac{27}{2} \sin 2\tau}^{\pi^{-1} \times} \\ + \frac{9}{2} \quad ,, \quad 2\tau - g' \\ + \frac{9}{2} \quad ,, \quad 2\tau + g' \\ + \frac{153}{8} e' \quad ,, \quad 2\tau - 2g' \\ + \frac{9}{8} e' \quad ,, \quad 2\tau + 2g',$$

and in δQ the additional terms (see Annex 7)

$$\begin{aligned} & \overbrace{\quad}^{n^{-1} \times} \\ & \frac{27}{2} \cos 2\tau \\ & + \frac{9}{2} \quad \text{,, } 2\tau - g' \\ & + \frac{9}{2} \quad \text{,, } 2\tau + g' \\ & + \frac{153}{8} e' \quad \text{,, } 2\tau - 2g' \\ & + \frac{9}{8} e' \quad \text{,, } 2\tau + 2g'. \end{aligned}$$

Combining the foregoing results, we have,

$$\begin{aligned} \delta P = & \frac{3}{2} e' t & + & \overbrace{\quad}^{n^{-1} \times} \\ & + \frac{3}{2} t \cos g' & & \circ \sin g' \\ & - \frac{15}{2} e' \quad \text{,, } 2\tau & + & \frac{27}{2} e' \quad \text{,, } 2\tau \\ & + \frac{21}{4} \quad \text{,, } 2\tau - g' & + & \frac{9}{2} \quad \text{,, } 2\tau - g' \\ & - \frac{3}{4} \quad \text{,, } 2\tau + g' & + & \frac{9}{2} \quad \text{,, } 2\tau + g' \\ & + \frac{9}{2} e' \quad \text{,, } 2g' & & \circ \quad \text{,, } 2g' \\ & + \frac{51}{2} e' \quad \text{,, } 2\tau - 2g' & + & \frac{153}{8} e' \quad \text{,, } 2\tau - 2g' \\ & \circ \quad \text{,, } 2\tau + 2g' & + & \frac{9}{8} e' \quad \text{,, } 2\tau + 2g', \end{aligned}$$

and

$$\begin{aligned} \delta Q = & \circ t \sin g' & + & \overbrace{\quad}^{n^{-1} \times} \\ & + \frac{15}{2} e' \quad \text{,, } 2\tau & + & \frac{27}{2} e' \quad \text{,, } 2\tau \\ & - \frac{21}{4} \quad \text{,, } 2\tau - g' & + & \frac{9}{2} \quad \text{,, } 2\tau - g' \end{aligned}$$

$$\begin{array}{ll}
 + \frac{3}{4} t \sin 2\tau + g' & + \overbrace{\frac{9}{2} \cos 2\tau + g'}^{n^{-1} x} \\
 0 \quad ,, \quad 2g' & 0 \quad ,, \quad 2g' \\
 - \frac{51}{2} e' \quad ,, \quad 2\tau - 2g' & + \frac{153}{8} e' \quad ,, \quad 2\tau - 2g' \\
 0 \quad ,, \quad 2\tau + 2g' & + \frac{9}{8} e' \quad ,, \quad 2\tau + 2g';
 \end{array}$$

whence also (see Annex 8)

$$\begin{array}{ll}
 n \int \delta Q dt = 0 \quad t \cos g' & + 0 \quad \overbrace{\sin g'}^{n^{-1} x} \\
 - \frac{15}{4} e' \quad ,, \quad 2\tau & + \frac{69}{8} e' \quad ,, \quad 2\tau \\
 + \frac{21}{8} \quad ,, \quad 2\tau - g' & + \frac{15}{16} \quad ,, \quad 2\tau - g' \\
 - \frac{3}{8} \quad ,, \quad 2\tau + g' & + \frac{39}{16} \quad ,, \quad 2\tau + g' \\
 0 \quad ,, \quad 2g' & 0 \quad ,, \quad 2g' \\
 + \frac{51}{4} e' \quad ,, \quad 2\tau - 2g' & + \frac{51}{16} e' \quad ,, \quad 2\tau - 2g' \\
 0 \quad ,, \quad 2\tau + 2g' & + \frac{9}{16} e' \quad ,, \quad 2\tau + 2g'.
 \end{array}$$

The equation for $\delta \epsilon$ may be written,

$$\frac{d^2 \delta \epsilon}{dt^2} + n^2 \delta \epsilon = n^2 \pi^2 \left(\delta P + 2n \int \delta Q dt \right),$$

and we have, (see Annex 9)

$$\begin{array}{ll}
 \delta P + 2n \int \delta Q dt = \frac{3}{2} e' t & + \overbrace{\sin g'}^{n^{-1} x} \\
 + \frac{3}{2} t \cos g' & 0 \quad \sin g' \\
 - 15 e' \quad ,, \quad 2\tau & + \frac{123}{4} e' \quad ,, \quad 2\tau \\
 + \frac{21}{2} \quad ,, \quad 2\tau - g' & + \frac{51}{8} \quad ,, \quad 2\tau - g'
 \end{array}$$

$$\begin{array}{rcl}
-\frac{3}{2} t \cos 2\tau + g' & + \overbrace{\frac{75}{8} \sin 2\tau + g'}^{n^{-1} \times} & \\
+ \frac{9}{2} e' \quad ,, \quad 2g' & 0 \quad ,, \quad 2g' & \\
+ 51 e' \quad ,, \quad 2\tau - 2g' & + \frac{51}{2} e' \quad ,, \quad 2\tau - 2g' & \\
0 \quad ,, \quad 2\tau + 2g' & + \frac{9}{4} e' \quad ,, \quad 2\tau + 2g'. &
\end{array}$$

Hence observing that a term $n^2 t \cos n\tau$ in $\frac{d^2 \delta \epsilon}{dt^2} + n^2 \delta \epsilon$, gives in $\delta \epsilon$ the terms

$$\frac{1}{1-n^2} t \cos n\tau + \frac{2n}{(1-n^2)^2} \frac{1}{n} \sin n\tau,$$

and a term $n \sin n\tau$ in $\frac{d^2 \delta \epsilon}{dt^2} + n^2 \delta \epsilon$, gives in $\delta \epsilon$ the term

$$\frac{1}{1-n^2} \frac{1}{n} \sin n\tau,$$

we have (see Annex 10, but restoring the factor f'),

$\delta \epsilon = f'$ into as follows, viz.

$$\begin{array}{rcl}
\frac{3}{2} m^2 e' t & + \overbrace{3 m^2 \sin g'}^{n^{-1} \times} & \\
+ \frac{3}{2} m^2 t \cos g' & 3 m^2 \sin g' & \\
+ 5 m^2 e' \quad ,, \quad 2\tau & - \frac{203}{12} m^2 e' \quad ,, \quad 2\tau & \\
- \frac{7}{2} m^2 \quad ,, \quad 2\tau - g' & + \frac{61}{24} m^2 \quad ,, \quad 2\tau - g' & \\
+ \frac{1}{2} m^2 \quad ,, \quad 2\tau + g' & - \frac{91}{24} m^2 \quad ,, \quad 2\tau + g' & \\
+ \frac{9}{2} m^2 e' \quad ,, \quad 2g' & - 18 m^2 e' \quad ,, \quad 2g' & \\
- 17 m^2 e' \quad ,, \quad 2\tau - 2g' & + \frac{85}{6} m^2 e' \quad ,, \quad 2\tau - 2g' & \\
0 \quad ,, \quad 2\tau + 2g' & - \frac{3}{4} m^2 e' \quad ,, \quad 2\tau + 2g'. &
\end{array}$$

The first column, containing the term in t and the terms $t \cos \arg.$, shows that the constant term of ϵ , and the terms involving the cosines of the same arguments, as obtained without attending to the variation of the solar excentricity, are correct as regards the first power of t , when for the constant excentricity e' we substitute $e' + f' t$. In fact, the above-mentioned expression (correct to e'^2) of $\frac{1}{\epsilon}$ gives

$$\begin{aligned} \epsilon &= 1 - \frac{1}{6} m^2 + \frac{3}{4} m^2 e'^2 \\ &\quad + \frac{3}{2} m^2 e' t \cos g' \\ &\quad - m^2 + \frac{5}{2} m^2 e'^2 \quad ,, \quad 2 \tau \\ &\quad - \frac{7}{2} m^2 e' t \quad ,, \quad 2 \tau - g' \\ &\quad + \frac{1}{2} m^2 e' t \quad ,, \quad 2 \tau + g' \\ &\quad + \frac{9}{4} m^2 e'^2 \quad ,, \quad 2 g' \\ &\quad - \frac{17}{2} m^2 e'^2 \quad ,, \quad 2 \tau - 2 g' \\ &\quad 0 \quad ,, \quad 2 \tau + 2 g', \end{aligned}$$

and putting therein $e' + f' t$ in the place of e' , we have the first column of the foregoing expression of $\delta \epsilon$.

The second column, involving $\sin \arg.$, contains the new periodic terms considered in Prof. Adams' Memoir of 1853, and the coefficients for the arguments g' , 2τ , $2 \tau - g'$, $2 \tau + g'$, agree with his values; observing that his terms belong to $\delta \frac{1}{\epsilon} = -\frac{\delta \epsilon}{\epsilon^2} = -\delta \epsilon$, so that the signs are reversed; those for the remaining arguments $2 g'$, $2 \tau - 2 g'$, $2 \tau + 2 g'$, are not given by him.

The equation for δv may be written,

$$\frac{d \delta v}{d t} = -2 n \delta \epsilon + m^2 n^2 \int \delta Q d t,$$

and we have (see Annex 11)

$$\begin{aligned} \frac{d \delta v}{d t} &= - \overbrace{\frac{n \times}{3 m^2 e' t}} \\ &\quad - 3 m^2 t \cos g' \quad - 6 m^2 \sin g' \\ &\quad + \frac{55}{4} m^2 e' \quad ,, \quad 2 \tau \quad + \frac{1019}{24} m^2 e' \quad ,, \quad 2 \tau \end{aligned}$$

$$\begin{array}{rcl}
 + \overbrace{\frac{77}{8} m^2}^{n \times} t \cos 2\tau - g' & - & \frac{199}{48} m^2 \sin 2\tau - g' \\
 - \frac{11}{8} m^2 & ,, & 2\tau + g' \\
 - 9 m^2 e' & ,, & 2g' \\
 + \frac{187}{8} m^2 e' & ,, & 2\tau - 2g' \\
 0 & ,, & 2\tau + 2g'
 \end{array}
 \begin{array}{rcl}
 + \frac{481}{48} m^2 & ,, & 2\tau + g' \\
 - 36 m^2 e' & ,, & 2g' \\
 - \frac{1207}{48} m^2 e' & ,, & 2\tau - 2g' \\
 + \frac{33}{16} m^2 e' & ,, & 2\tau + 2g'.
 \end{array}$$

whence, integrating by the formulæ

$$\begin{aligned}
 \int t \cos n\pi t \, dt &= \frac{1}{n\pi} t \sin n\pi t + \frac{1}{n^2 \pi^2} \cos n\pi t, \\
 \int \sin n\pi t \, dt &= -\frac{1}{n\pi} \cos n\pi t,
 \end{aligned}$$

we have (see Annex 12, but restoring the factor f'),

$\delta v = f'$ into as follows, viz.

$$\begin{array}{rcl}
 - \frac{3}{2} m^2 n e' f^2 & & \\
 - 3 m t \sin g' & + & \overbrace{-\frac{1}{3} + 6 m^2}^{n^{-1} \times} \cos g' \\
 - \frac{55}{8} m^2 e' & ,, & 2\tau \\
 + \frac{77}{16} m^2 & ,, & 2\tau - g' \\
 - \frac{11}{16} m^2 & ,, & 2\tau + g' \\
 - \frac{9}{2} m e' & ,, & 2g' \quad \left(-\frac{9}{4} + 18 m^2 \right) e' \\
 + \frac{187}{8} m^2 e' & ,, & 2\tau - 2g' \\
 0 & ,, & 2\tau + 2g'
 \end{array}
 \begin{array}{rcl}
 - \frac{74}{3} m^2 e' & ,, & 2\tau \\
 + \frac{215}{48} m^2 & ,, & 2\tau - g' \\
 - \frac{257}{48} m^2 & ,, & 2\tau + g' \\
 + \frac{2239}{96} m^2 e' & ,, & 2\tau - 2g' \\
 - \frac{33}{32} m^2 e' & ,, & 2\tau + 2g'.
 \end{array}$$

The first column, containing $t \sin \arg.$, may be obtained from the before-mentioned expression (accurate to e'^2) of v , by substituting therein $e' + f' t$ in the place of e' .

The term $-\frac{3}{2}m^2 n e' f' t^2$; or, as it may be written, $-\frac{3}{2}m^2 \int n [(e' + f' t)^2 - e'^2] dt$, is the first term of the acceleration; the other terms of the second column are the new periodic terms in δv , considered by Prof. Adams; the coefficients for the arguments $g', 2\tau, 2\tau - g', 2\tau + g'$, agreeing with his values, but those for the remaining arguments $2g', 2\tau - 2g', 2\tau + 2g'$ not being given by him.

III.

Proceeding now to the calculation of the term in m^4 of the acceleration, we have,

$$\frac{d\delta v}{dt} = -\frac{2}{e} \frac{dv}{dt} \delta e + \frac{m^2 n^2}{e^2} \left(C + \int \delta Q dt \right),$$

where the non-periodic part of δe is of the form,

$$\delta e = \left(\frac{3}{2} m^2 + \square m^4 \right) e' f' t,$$

and it is in the first place necessary to find the value of the numerical coefficient $\square$, in fact to calculate the secular part of δe as far as m^4 . Reverting to the equation

$$\begin{aligned} \frac{d^2 \delta e}{dt^2} + n^2 \delta e = \\ \left(n^2 + \frac{2n^2}{e^2} - 3 \left(\frac{dv}{dt} \right)^2 \right) \delta e + m^2 n^2 \left(\delta P + \frac{2}{e} \frac{dv}{dt} \left(C + \int \delta Q dt \right) \right), \end{aligned}$$

and as before omitting in the process the factor f' .

The part $\left(n^2 + \frac{2n^2}{e^2} - 3 \left(\frac{dv}{dt} \right)^2 \right) \delta e$ contains (see Annex 13), a term

$$= -\frac{321}{8} m^4 n^2 e' t.$$

The part of $m^2 n^2 \delta P$, which involves δe , contains (see Annex 14) a term

$$= -\frac{495}{32} m^4 n^2 e' t.$$

The part of $m^2 n^2 \delta P$, which depends on δv , contains a term

$$= -\frac{15}{4} m^4 n^2 e' t.$$

The part of $m^2 n^2 \delta P$, depending on $\delta \epsilon'$ and $\delta v'$, is found (see Annex 18) to contain, besides the term $\frac{3}{2} m^4 n^2 e' t$ in m^2 already obtained, a new term

$$= -\frac{647}{32} m^4 n^2 e' t.$$

And finally the part $m^2 n^2 \frac{2}{\epsilon} \frac{dv}{dt} \left(C + \int \delta Q dt \right)$ is found (see Annex 19) to contain a term

$$\left(2 \cdot \frac{-1455}{32} + \frac{675}{32} \right) - \frac{2235}{32} m^4 n^2 e' t.$$

where the component coefficient $-\frac{1455}{32}$, which arises from the new periodic terms of $\delta \epsilon$ and δv is separately calculated (see Annex 21).

Hence $\frac{d^2 \delta \epsilon}{dt^2} + n^2 \delta \epsilon$ contains the term

$$\left(\square = \frac{381}{8} - \frac{495}{32} - \frac{15}{4} - \frac{647}{32} - \frac{2235}{32} \right) - \frac{1973}{32} m^4 n^2 e' t,$$

and this gives in $\delta \epsilon$ the term

$$- \frac{1973}{32} m^4 e' t,$$

so that, restoring the term in m^2 , and the common factor f' , the complete secular term of $\delta \epsilon$ is

$$\delta \epsilon = \left(\frac{3}{2} m^2 - \frac{1973}{32} m^4 \right) e' f' t,$$

which, as will be shown, Art. IV., agrees with Prof. Adams' result.

Resuming now the equation,

$$\frac{d \delta v}{dt} = -\frac{2}{\epsilon} \frac{dv}{dt} \delta \epsilon + \frac{m^2 n^2}{\epsilon^2} \left(C + \int \delta Q dt \right).$$

the part $-\frac{2}{c} \frac{dv}{dt} \delta c$ contains (see Annex 22) the term

$$\left(\frac{1973}{16} + \frac{275}{8} = \right) \frac{2523}{16} m^4 n e' t,$$

and the part $\frac{m^2 n^3}{c^2} \left(C + \int \delta Q dt \right)$ contains (see Annex 23) the term

$$\left(\frac{45}{8} - \frac{1455}{32} = \right) - \frac{1275}{32} m^4 n e' t,$$

so that we have in $\frac{d\delta v}{dt}$ the term

$$\left(\frac{2523}{16} - \frac{1275}{32} = \right) \frac{3771}{32} m^4 n e' t,$$

giving in δv the term

$$\frac{3771}{64} m^4 n e' t^2,$$

or, restoring the term in m^2 and the common factor f' , the complete secular term of δv is

$$\delta v = \left(-\frac{3}{2} m^2 + \frac{3771}{64} m^4 \right) n e' f' t^2,$$

which agrees with the value obtained by Prof. Adams. It is right to remark that the m of Prof. Adams is different from that of the present Memoir; we have in fact,

$$m \text{ (Adams)} = m \left\{ 1 + \left(\frac{3}{2} m^2 - \frac{3771}{64} m^4 \right) 2 e' f' t \right\}$$

in the notation of the present Memoir; but as f'^2 is throughout neglected, we may in the foregoing expression of the secular part of δv substitute the m of Prof. Adams. And then if the term be written in the form

$$\delta v = \left(-\frac{3}{2} m^2 + \frac{3771}{64} m^4 \right) \int [(e' + f' t)^2 - e'^2] n dt,$$

the two results are seen to agree together. But as regards the before-mentioned secular term,

$$\delta e = \left(\frac{3}{2} m^2 - \frac{1973}{32} m^4 \right) e' f' t,$$

the identification is less easy, and I shall consider it in the following article.

IV.

It will be convenient to write M, N, A, E' , in place of the m, n, a, e' , of the foregoing part of the present Memoir, and to now use m, n, e' , in the significations in which they are employed by Prof. Adams; E' (the constant part of the solar excentricity) is his E' , and his e' is $E' + f' t$. As to his symbols a, a_1 , these, I think, ought to have been represented, and I shall here represent them by a, a_1 .* And I take a such that $n^2 a^3 = \text{Sum of the masses of the Earth and Moon}$; or, taking this to be unity, we have $N^2 A^3 = 1, n^2 a^3 = 1$.

The formulæ of Prof. Adams' memoir, which it will be necessary to make use of, may be written

$$\begin{aligned} \frac{a}{r} = & 1 - \frac{11}{8} m^2 - \frac{201}{16} m^4 e'^2 \\ & - \frac{3}{2} m^2 e' \cos g' \\ & + m^2 - \frac{5}{2} m^2 e'^2 \quad ,, \quad 2 r \\ & + \frac{7}{2} m^2 e' \quad ,, \quad 2 r - g' \\ & - \frac{1}{2} m^2 e' \quad ,, \quad 2 r + g' \end{aligned}$$

the sine terms being disregarded.

$$n = N \left\{ 1 + \left(-\frac{3}{2} m^2 + \frac{3771}{64} m^4 \right) \frac{1}{2} E' f' t \right\}.$$

(whence also

$$m = M \left\{ 1 + \left(\frac{3}{2} m^2 - \frac{3771}{64} m^4 \right) \frac{1}{2} E' f' t \right\}$$

* Plana, in his Lunar Theory, uses the three letters a, a_1, a ; his a and a_1 being such that $n^2 a^3 = \text{Sum of the masses of the Earth and Moon}$. There is an obvious inconvenience in writing a, a_1 , in the place of his a, a_1 .

since $m = \frac{n'}{n}$, $M = \frac{N'}{N}$).

$$\frac{1}{n} = a, \frac{1}{n} \left\{ 1 + m^2 - \frac{197}{64} m^4 + \left(\frac{3}{2} m^2 - \frac{3867}{64} m^4 \right) e^2 \right\},$$

$$1 = \frac{a}{a'} \left\{ 1 - \frac{1}{2} m^2 + \frac{13}{4} m^4 + \left(-\frac{3}{4} m^2 + \frac{3201}{64} m^4 \right) e^2 \right\},$$

which formulae, observing that $\frac{1}{e + \delta e} = \frac{A}{r}$ lead to the value of δe , and we should obtain for the secular part the foregoing expression, which will now be

$$\delta e = \left(\frac{3}{2} M^2 - \frac{1973}{32} M^4 \right) E' f' t.$$

We in fact have

$$a' = \frac{1}{n} = a, \frac{1}{n} \left\{ 1 + m^2 - \frac{197}{64} m^4 + \left(\frac{3}{2} m^2 - \frac{3867}{64} m^4 \right) e^2 \right\},$$

And thence

$$a = a' \left\{ 1 + \frac{2}{3} m^2 - \frac{197}{96} m^4 + \left(m^2 - \frac{3867}{96} m^4 \right) e^2 \right. \\ \left. - \frac{1}{9} \left(m^4 + 3 m^4 e^2 \right) \right\}$$

$$= a' \left\{ 1 + \frac{2}{3} m^2 - \frac{623}{288} m^4 + \left(m^2 - \frac{3899}{96} m^4 \right) e^2 \right\},$$

but

$$1 = \frac{a}{a'} \left\{ 1 - \frac{1}{2} m^2 + \frac{13}{4} m^4 + \left(-\frac{3}{4} m^2 + \frac{3201}{64} m^4 \right) e^2 \right\};$$

and therefore

$$a = a' \left\{ 1 + \frac{2}{3} m^2 - \frac{623}{288} m^4 + \left(m^2 - \frac{3899}{96} m^4 \right) e^2 \right. \\ - \frac{1}{2} m^2 + \frac{13}{4} m^4 - \frac{1}{2} m^4 e^2 \\ - \frac{1}{3} m^4 + \left(-\frac{3}{4} m^2 + \frac{3201}{64} m^4 \right) e^2 \\ \left. - \frac{1}{2} m^4 e^2 \right\}$$

$$= a' \left\{ 1 + \frac{1}{6} m^2 + \frac{217}{288} m^4 + \left(\frac{1}{4} m^2 + \frac{1613}{192} m^4 \right) e^2 \right\};$$

and hence, since for the non-periodic part

$$\frac{a}{r} = 1 - \frac{11}{8} m^4 - \frac{201}{16} m^4 e^2,$$

we find

$$\begin{aligned} \frac{a}{r} &= 1 + \frac{1}{6} m^2 + \frac{217}{288} m^4 + \left(\frac{1}{4} m^2 + \frac{1613}{192} m^4 \right) e^2 \\ &\quad - \frac{11}{8} m^4 - \frac{201}{16} m^4 e^2 \\ &= 1 + \frac{1}{6} m^2 - \frac{179}{288} m^4 + \left(\frac{1}{4} m^2 - \frac{799}{192} m^4 \right) e^2 \\ &= 1 + \frac{1}{6} m^2 - \frac{179}{288} m^4 + \left(\frac{1}{4} m^2 - \frac{799}{192} m^4 \right) E^2 + \left(\frac{1}{4} m^2 - \frac{799}{192} m^4 \right) 2 E' f' t. \end{aligned}$$

But

$$\frac{\dot{A}}{a} = \left(\frac{n}{N} \right)^{\frac{1}{2}} = 1 + \left(-m^2 + \frac{3771}{96} m^4 \right) 2 E' f' t;$$

and therefore

$$\begin{aligned} \frac{\dot{A}}{r} &= 1 + \frac{1}{6} m^2 - \frac{179}{288} m^4 + \left(\frac{1}{4} m^2 - \frac{799}{192} m^4 \right) E^2 + \left(\frac{1}{4} m^2 - \frac{799}{192} m^4 \right) 2 E' f' t \\ &\quad + \left(-m^2 + \frac{3771}{96} m^4 \right) 2 E' f' t \\ &\quad - \frac{1}{6} m^4 \cdot 2 E' f' t \\ &= 1 + \frac{1}{6} m^2 - \frac{179}{288} m^4 + \left(\frac{1}{4} m^2 - \frac{799}{192} m^4 \right) E^2 + \left(-\frac{3}{4} m^2 + \frac{2237}{64} m^4 \right) 2 E' f' t. \end{aligned}$$

But we have

$$m = M \left\{ 1 + \left(\frac{3}{2} M^2 - \frac{3771}{64} M^4 \right) 2 E' f' t \right\};$$

and thence in the foregoing expression

$$\begin{aligned} m^2 &= M^2 + 3 M^4 \cdot 2 E' f' t. \\ m^4 &= M^4; \end{aligned}$$

and therefore

$$\begin{aligned} \frac{A}{r} = & 1 + \frac{1}{6} M^2 - \frac{179}{288} M^4 + \left(\frac{1}{4} M^2 - \frac{799}{192} M^4 \right) E^2 + \left(-\frac{3}{4} M^2 + \frac{2237}{64} M^4 \right) {}_2E'f't \\ & + \frac{1}{2} M^4 \cdot {}_2E'f't \\ & - 1 + \frac{1}{6} M^2 - \frac{179}{288} M^4 + \left(\frac{1}{4} M^2 - \frac{799}{192} M^4 \right) E^2 + \left(-\frac{3}{4} M^2 + \frac{2269}{64} M^4 \right) {}_2E'f't; \end{aligned}$$

and observing that in the periodic terms we may write A , in the place of a , and neglect the sine terms, we have

$$\begin{aligned} \frac{A}{r} = \frac{1}{\zeta + \delta\zeta} = & 1 + \frac{1}{6} M^2 - \frac{179}{288} M^4 + \left(\frac{1}{4} M^2 - \frac{799}{192} M^4 \right) E^2 \\ & + \left(-\frac{3}{4} M^2 + \frac{2269}{64} M^4 \right) {}_2E'f't \\ & - \frac{3}{2} m^2 e' \cos g' \\ & + m^2 \left(1 - \frac{5}{2} e^2 \right) \quad ,, \quad {}_2\tau \\ & + \frac{7}{2} m^2 e' \quad ,, \quad {}_2\tau - g' \\ & - \frac{1}{2} m^2 e' \quad ,, \quad {}_2\tau + g', \end{aligned}$$

say $\frac{1}{\zeta + \delta\zeta} = 1 + X$; and thence $\zeta + \delta\zeta = \frac{1}{1+X} = 1 - X + X^2$, the non-periodic part whereof is

$$\begin{aligned} 1 - \frac{1}{6} M^2 + \frac{179}{128} M^4 + \left(-\frac{1}{4} M^2 + \frac{179}{192} M^4 \right) E^2 + \left(\frac{3}{4} M^2 - \frac{2269}{64} M^4 \right) {}_2E'f't \\ + \frac{1}{36} M^4 \quad + \frac{1}{12} M^4 E^2 \quad + \frac{1}{4} M^4 \cdot {}_2E'f't \\ + \frac{1}{2} \frac{9}{4} m^4 e^2 \\ + \frac{1}{2} m^4 \left(1 - 5 e^2 \right) \\ + \frac{1}{2} \frac{49}{4} m^4 e^2 \\ + \frac{1}{2} \frac{1}{4} m^4 e'^2, \end{aligned}$$

where the terms in m^4 and $m^4 e^2$ are

$$= \frac{1}{2} m^4 + \left(\frac{9}{8} - \frac{5}{2} + \frac{49}{8} + \frac{1}{8} \right) \frac{39}{8} m^4 e^2,$$

which are

$$= \frac{1}{2} M^4 + \frac{39}{8} M^4 E^2 + \frac{39}{8} M^4 \cdot 2 E' f' t,$$

so that the foregoing expression of the non-periodic part of $\epsilon + \delta \epsilon$ is

$$\begin{aligned} &= 1 - \frac{1}{6} M^2 + \left(\frac{179}{128} + \frac{1}{36} + \frac{1}{2} \right) \frac{2219}{1152} M^4 \\ &\quad + \left(-\frac{1}{4} M^2 + \left(\frac{179}{192} + \frac{1}{12} + \frac{39}{8} \right) \frac{1131}{192} M^4 \right) E^2 \\ &\quad + \left(\frac{3}{4} M^2 + \left(-\frac{2269}{64} - \frac{1}{4} + \frac{39}{8} \right) - \frac{1973}{64} M^4 \right) 2 E' f' t; \end{aligned}$$

or the secular term of $\delta \epsilon$ is

$$= \left(\frac{3}{4} M^2 - \frac{1973}{64} M^4 \right) 2 E' f' t,$$

which is the required formula.

V.

It is interesting to see how the coefficient $\frac{3771}{64}$ is made up. In Prof. Adams' Memoir we have

$$\begin{aligned} \frac{3771}{64} &= \\ &= -\frac{3}{2} - \frac{3}{4} \quad \left(= -\frac{9}{4} \right) \\ &+ \frac{15}{4} + \frac{135}{64} - \frac{117}{8} + \frac{495}{128} - \frac{285}{16} - \frac{147}{16} - \frac{3}{16} - \frac{1323}{256} - \frac{27}{256} \\ &\quad \left(= -\frac{2391}{64} \right) \\ &+ \frac{9}{2} - \frac{27}{4} - \frac{45}{2} - \frac{45}{2} - \frac{15}{2} - \frac{495}{32} + \frac{285}{4} - \frac{147}{4} - \frac{3}{4} + \frac{441}{8} + \frac{441}{8} + \frac{9}{8} + \frac{9}{8} \\ &\quad \left(= +\frac{3153}{32} \right). \end{aligned}$$

where it may be remarked that the terms

$$\frac{495}{128} - \frac{285}{16} = \left(-\frac{1785}{128} \right)$$

and

$$-\frac{495}{32} + \frac{285}{4} = \left(+4 \cdot \frac{1785}{128} \right)$$

make together $3 \cdot \frac{1785}{128} = \frac{5355}{128}$, and that it is in fact by the addition of these terms that Plana's coefficient $\frac{2187}{128}$ is changed into $\frac{3771}{64}$.

But in the present Memoir the coefficient $\frac{3771}{64}$ is obtained by means of an entirely different set of component numbers, viz. we have

$$\frac{3771}{64} = -\frac{381}{8} + \frac{495}{32} + \frac{15}{4} + \frac{647}{32} + \frac{1455}{16} - \frac{675}{32} + \frac{275}{16} + \frac{45}{16} - \frac{1455}{64}.$$

I had imagined, from the way in which the numbers $\frac{1455}{16} - \frac{1455}{64}$ presented themselves, that, if they were omitted, Plana's value $\frac{2187}{128}$ would have been obtained; but the result shows that this is not so.

As just deduced from the formula of Prof. Adams, the number $\frac{1973}{64}$ is obtained as follows, viz.

$$\begin{aligned} \frac{1973}{64} = & \left(-\frac{3771}{96} - 1 \right) - \frac{1}{3} - \frac{1}{2} + \left(\frac{3153}{64} + \frac{3}{4} \right) - \frac{1}{2} - \frac{201}{16} + \frac{3771}{96} - \frac{1}{6} - \frac{1}{2} + \frac{1}{4} - \frac{39}{8} \\ & = -1 - \frac{1}{3} - \frac{1}{2} + \frac{3}{4} - \frac{1}{2} - \frac{1}{6} - \frac{1}{2} + \frac{1}{4} \quad \left(= -1 \right) \\ & + \frac{3153}{64} - \frac{201}{16} - \frac{39}{8}, \end{aligned}$$

where *ut supra*

$$\frac{3153}{64} = \frac{1}{2} \left\{ \frac{9}{2} - \frac{27}{4} - \frac{45}{2} - \frac{45}{2} - \frac{15}{2} - \frac{495}{32} + \frac{285}{4} - \frac{147}{4} - \frac{3}{4} + \frac{441}{8} + \frac{441}{8} + \frac{9}{8} + \frac{9}{8} \right\},$$

$-\frac{201}{16}$ is a number occurring in his Memoir, and which is in effect obtained irrespectively of the new periodic terms, and $-\frac{39}{8}$ is a number obtained as above, irrespectively of the new periodic terms. According to the method of the present Memoir, the number $\frac{1973}{64}$ was obtained in the form

$$\frac{1973}{64} = -\frac{1}{2} \left(\frac{381}{8} - \frac{495}{32} - \frac{15}{4} - \frac{647}{32} - \frac{1455}{16} + \frac{675}{32} \right).$$

VI.

If the investigation were pursued further, a question would arise as to the proper form to be given to the arguments; for in these, $nt + \iota$ seems to stand in the place of v , the value whereof is

$$v = nt + \iota - \left(\frac{3}{2} m^2 - \frac{3771}{64} m^4 \right) n e' f' t^2,$$

say $v = nt + \iota + k n e' f' t^2$, and it might be considered that in the arguments $nt + \iota$ should be changed into $nt + \iota + k n e' f' t^2$, or, what is the same thing, that τ should be changed into $\tau + k n e' f' t^2$, but that g' should remain unaltered (this assumes that there is not in the Sun's longitude any term corresponding to the acceleration). The arguments, instead of being of the simple form kt , would thus be of the form $kt + k_2 f' t^2$. But this would not only increase the difficulty of integration, but would be inconsistent with the general plan of the solution; and it would seem to be the proper course to imagine the cosine or sine of such an argument to be developed $\left(\frac{\cos}{\sin} kt + k_2 f' t^2 \right) = \frac{\cos}{\sin} kt \mp k_2 f' t^2 \frac{\sin}{\cos} kt$ in such manner as to bring the secular part of the argument outside the cos or sin; this is, in fact, the form which the solution takes when the arguments are left throughout in their original form, for the terms of the form $f' t^2 \frac{\cos}{\sin} \arg.$ would present themselves in the subsequent approximations. But I shall not at present further examine the question.

Annexes containing the Details of the Calculation.

Annex 1.

Calculation of part of δP .

$$\delta P = \frac{1}{\epsilon'^3} \left(\frac{1}{2} + \frac{3}{2} \cos 2v - 2v' \right) \delta \epsilon$$

$$+ \frac{\epsilon}{\epsilon'^3} \left(-3 \sin 2v - 2v' \right) \delta v.$$

For $\cos 2v - 2v'$, $\sin 2v - 2v'$, see Annex 3.

$\frac{1}{2} + \frac{3}{2} \cos 2v - 2v' =$ $\frac{1}{2}$ $+ \frac{3}{2} \cos 2v$ $+ 3v' ,, 2v - g'$ $- 3v' ,, 2v + g'$	$\frac{1}{\epsilon'^3} =$ 1 $+ 3v' \cos g'.$
---	--

Product is =

$$\frac{1}{2} + \frac{3}{2} v' \cos g'$$

$$+ \frac{3}{2} \cos 2v + \frac{9}{2} v' \left(\frac{1}{2} \cos 2v - g' + \frac{1}{2} \cos 2v + g' \right)$$

$$+ 3v' ,, 2v - g'$$

$$- 3v' ,, 2v + g'$$

$$= \frac{1}{2}$$

$$+ \frac{3}{2} v' \cos g'$$

$$+ \frac{3}{2} ,, 2v$$

$$\left(+3 + \frac{9}{4} = \right) + \frac{21}{4} v' ,, 2v - g'$$

$$\left(-3 + \frac{9}{4} = \right) - \frac{3}{4} v' ,, 2v + g'.$$

which is the coefficient of $\delta \epsilon$.

And

$$\begin{array}{l|l}
 -3 \sin 2v - 2v' = & \frac{1}{\epsilon^{\frac{1}{3}}} = \\
 -3 \sin 2v & 1 \\
 -6 \epsilon' \sin 2v - g' & + 3 \epsilon' \cos g'. \\
 + 6 \epsilon' \sin 2v + g' &
 \end{array}$$

Product is =

$$\begin{aligned}
 & -3 \sin 2v - 9 \epsilon' \left(\frac{1}{2} \sin 2v - g' + \frac{1}{2} \sin 2v + g' \right) \\
 & -6 \epsilon' \sin 2v - g' \\
 & + 6 \epsilon' \sin 2v + g' \\
 = & -3 \sin 2v \\
 & \left(-6 - \frac{9}{2} \right) - \frac{21}{2} \epsilon' \sin 2v - g' \\
 & \left(+6 - \frac{9}{2} \right) + \frac{3}{2} \epsilon' \sin 2v + g';
 \end{aligned}$$

or, since $\epsilon = 1$, this is the coefficient of δv .

Annex 2.

Calculation of part of δQ .

$$\begin{aligned}
 \delta Q = & \frac{\epsilon}{\epsilon^{\frac{1}{3}}} (-3 \sin 2v - 2v') \delta \epsilon \\
 & + \frac{\epsilon^2}{\epsilon^{\frac{1}{3}}} (-3 \cos 2v - 2v') \delta v.
 \end{aligned}$$

For $\cos 2v - 2v'$, $\sin 2v - 2v'$, see Annex 3.

$$\begin{array}{l|l}
 -3 \sin 2v - 2v' = & \frac{1}{\epsilon^{\frac{1}{3}}} = \\
 -3 \sin 2v & 1 \\
 -6 \epsilon' \sin 2v - g' & + 3 \epsilon' \cos g'. \\
 + 6 \epsilon' \sin 2v + g' &
 \end{array}$$

Product is =

$$\begin{aligned}
 & -3 \sin 2\tau - 9e' \left(\frac{1}{2} \sin 2\tau - g' + \frac{1}{2} \sin 2\tau + g' \right) \\
 & - 6e' \sin 2\tau - g' \\
 & - 6e' \sin 2\tau + g' \\
 & = -3 \sin 2\tau \\
 & \left(-6 - \frac{9}{2} = \right) - \frac{21}{2} e' \sin 2\tau - g' \\
 & \left(+6 - \frac{9}{2} = \right) + \frac{3}{2} e' \sin 2\tau + g';
 \end{aligned}$$

or, since $e = 1$, this is the coefficient of $\delta\epsilon$.

$$\begin{array}{l|l}
 -3 \cos 2\tau - 2e' & \frac{1}{e'^2} = \\
 -3 \cos 2\tau & 1 \\
 -6e' \sin 2\tau - g' & + 3e' \cos g' \\
 +6e' \sin 2\tau + g' &
 \end{array}$$

Product is =

$$\begin{aligned}
 & -3 \cos 2\tau - 9e' \left(\frac{1}{2} \cos 2\tau - g' + \frac{1}{2} \cos 2\tau + g' \right) \\
 & - 6e' \sin 2\tau - g' \\
 & + 6e' \sin 2\tau + g' \\
 & = -3 \cos 2\tau \\
 & \left(-6 - \frac{9}{2} = \right) - \frac{21}{2} e' \sin 2\tau - g' \\
 & \left(+6 - \frac{9}{2} = \right) + \frac{3}{2} e' \sin 2\tau + g';
 \end{aligned}$$

or, since $e^2 = 1$, this is the coefficient of δv .

Annex 3.

Calculation of $\frac{\cos}{\sin} 2v - 2v'$.

$$\begin{aligned}
 v - v' &= \tau - 2e' \sin g' \\
 2v - 2v' &= 2\tau - 4e' \sin g' \\
 \cos 2v - 2v' &= \cos 2\tau \\
 &+ \sin 2\tau \cdot 4e' \sin g' \\
 &= \cos 2\tau \\
 &+ 2e' \sin 2\tau - g' \\
 &- 2e' \sin 2\tau + g' \\
 \sin 2v - 2v' &= \sin 2\tau \\
 &- \cos 2\tau \cdot 4e' \sin g' \\
 &= \sin 2\tau \\
 &+ 2e' \sin 2\tau - g' \\
 &- 2e' \sin 2\tau + g'
 \end{aligned}$$

The expressions are calculated (*post*, Annex 16) as far as m^2 .

Annex 4.

Calculation of a part of δP .

$$\delta P = \epsilon \left\{ \left(\frac{1}{2} + \frac{3}{2} \cos 2v - 2v' \right) \delta \frac{1}{\epsilon^2} + \left(3 \sin 2v - 2v' \right) \frac{\delta v'}{\epsilon^2} \right\}.$$

For $\cos 2v - 2v'$, $\sin 2v - 2v'$, see Annex 3.

$\frac{1}{2} + \frac{3}{2} \cos 2v - 2v' =$	$\delta \frac{1}{\epsilon^2} =$
$\frac{1}{2}$	$3e' t$
$+ \frac{3}{2} \cos 2\tau$	$+ 3 t \cos g'$
$+ 3e' \sin 2\tau - g'$	$+ 9e' \sin 2g'$
$- 3e' \sin 2\tau + g'$	

Product is =

$$\begin{aligned}
 & \frac{3}{2} e' t \\
 & + \frac{9}{2} e' t \cos 2\tau \\
 & + \frac{3}{2} \quad \quad \quad \text{,, } g' \\
 & + \frac{9}{2} \left(\frac{1}{2} t \cos 2\tau - g' + \frac{1}{2} t \cos 2\tau + g' \right) \\
 & + 9 e' \left(\frac{1}{2} \quad \quad \quad \text{,, } 2\tau - 2g' + \frac{1}{2} \quad \quad \quad \text{,, } 2\tau \right) \\
 & - 9 e' \left(\frac{1}{2} \quad \quad \quad \text{,, } 2\tau + \frac{1}{2} \quad \quad \quad \text{,, } 2\tau + 2g' \right) \\
 & + \frac{9}{2} e' t \cos 2g' \\
 & + \frac{27}{2} e' \left(\frac{1}{2} t \cos 2\tau - 2g' + \frac{1}{2} t \cos 2\tau + 2g' \right).
 \end{aligned}$$

which is =

$$\begin{aligned}
 & \frac{3}{2} e' t \\
 & + \frac{3}{2} t \cos g' \\
 & \left(\frac{9}{2} + \frac{9}{2} - \frac{9}{2} = \right) + \frac{9}{2} e' \quad \quad \quad \text{,, } 2\tau \\
 & + \frac{9}{4} \quad \quad \quad \text{,, } 2\tau - g' \\
 & + \frac{9}{4} \quad \quad \quad \text{,, } 2\tau + g' \\
 & + \frac{9}{2} e' \quad \quad \quad \text{,, } 2g' \\
 & \left(\frac{9}{2} + \frac{27}{4} = \right) + \frac{45}{4} e' \quad \quad \quad \text{,, } 2\tau - 2g' \\
 & \left(-\frac{9}{2} + \frac{27}{4} = \right) + \frac{9}{4} e' \quad \quad \quad \text{,, } 2\tau + 2g' \\
 \\
 & \begin{array}{l} 3 \sin 2\vartheta - 2\vartheta' = \\ \quad 3 \sin 2\tau \\ + 6 e' \quad \quad \quad \text{,, } 2\tau - g' \\ - 6 e' \quad \quad \quad \text{,, } 2\tau + g' \end{array} \quad \left| \quad \begin{array}{l} \frac{3\vartheta'}{e'^3} = \\ \quad 2 t \sin g' \\ + \frac{11}{2} e' \quad \quad \quad \text{,, } 2g'; \end{array} \right.
 \end{aligned}$$

Annex 5.

Calculation of a part of δQ , viz.

$$\delta Q = e^3 \left[\left(-\frac{3}{2} \sin 2v - 2v' \right) \delta \frac{1}{e^3} + (3 \cos 2v - 2v') \frac{\delta v'}{e^3} \right],$$

$-\frac{3}{2} \sin 2v - 2v' =$	$\delta \frac{1}{e^3} =$
$-\frac{3}{2} \sin 2v$	$3e' t$
$-3e' \text{ ,, } 2v - g'$	$+3 t \cos g'$
$+3e' \text{ ,, } 2v + g'$	$+9e' \text{ ,, } 2g'$

Product is

$$\begin{aligned} & -\frac{9}{2} e' t \sin 2v \\ & -\frac{9}{2} \left(\frac{1}{2} t \sin 2v + g' + \frac{1}{2} t \sin 2v - g' \right) \\ & -9e' \left(\frac{1}{2} \text{ ,, } 2v + \frac{1}{2} \text{ ,, } 2v - 2g' \right) \\ & +9e' \left(\frac{1}{2} \text{ ,, } 2v + 2g' + \frac{1}{2} \text{ ,, } 2v \right) \\ & -\frac{27}{2} e' \left(\frac{1}{2} \text{ ,, } 2v + 2g' + \frac{1}{2} \text{ ,, } 2v - 2g' \right), \end{aligned}$$

which is =

$$\begin{aligned} & \left(-\frac{9}{2} - \frac{9}{2} + \frac{9}{2} = \right) -\frac{9}{2} e' t \sin 2v \\ & \quad -\frac{9}{4} \text{ ,, } 2v - g' \\ & \quad -\frac{9}{4} \text{ ,, } 2v + g' \\ & \left(-\frac{9}{2} - \frac{27}{4} = \right) -\frac{45}{4} e' \text{ ,, } 2v - 2g' \\ & \left(+\frac{9}{2} - \frac{27}{4} = \right) -\frac{9}{4} e' \text{ ,, } 2v + 2g'; \end{aligned}$$

and

$$\begin{array}{l|l}
 \cos 2\tau - 2\tau' = & \frac{3\tau'}{\epsilon'^2} = \\
 3 \cos 2\tau & 2 \quad t \sin g' \\
 + 6\epsilon' \quad ,, \quad 2\tau - g' & + \frac{11}{2}\epsilon' \quad ,, \quad 2g', \\
 - 6\epsilon' \quad ,, \quad 2\tau + g' &
 \end{array}$$

Product is

$$\begin{aligned}
 & 6 \left(\frac{1}{2} t \sin 2\tau + 2g' - \frac{1}{2} t \sin 2\tau - g' \right) \\
 & + 12\epsilon' \left(\frac{1}{2} \quad ,, \quad 2\tau \quad - \frac{1}{2} \quad ,, \quad 2\tau - 2g' \right) \\
 & - 12\epsilon' \left(\frac{1}{2} \quad ,, \quad 2\tau + 2g' - \frac{1}{2} \quad ,, \quad 2\tau \quad \right) \\
 & + \frac{33}{2}\epsilon' \left(\frac{1}{2} \quad ,, \quad 2\tau + 2g' - \frac{1}{2} \quad ,, \quad 2\tau - 2g' \right);
 \end{aligned}$$

which is =

$$\begin{aligned}
 & (6 + 6 =) \quad 12\epsilon' \quad t \sin 2\tau \\
 & \quad - 3 \quad ,, \quad 2\tau - g' \\
 & \quad + 3 \quad ,, \quad 2\tau + g' \\
 & \left(-6 - \frac{33}{4} = \right) - \frac{57}{4}\epsilon' \quad ,, \quad 2\tau - 2g' \\
 & \left(-6 + \frac{33}{4} = \right) + \frac{9}{4}\epsilon' \quad ,, \quad 2\tau + 2g'.
 \end{aligned}$$

Adding the two products together, and observing that $\epsilon^2 = 1$, the required terms are

$$\begin{aligned}
 & \left(-\frac{9}{2} + 12 = \right) \cdot \frac{15}{2}\epsilon' t \sin 2\tau \\
 & \left(-\frac{9}{4} - 3 = \right) - \frac{21}{4} \quad ,, \quad 2\tau - g' \\
 & \left(-\frac{9}{4} + 3 = \right) + \frac{3}{4} \quad ,, \quad 2\tau + g' \\
 & \left(-\frac{45}{4} - \frac{57}{4} = \right) - \frac{51}{2}\epsilon' \quad ,, \quad 2\tau - 2g' \\
 & \left(-\frac{9}{4} + \frac{9}{4} = \right) \quad 0 \quad ,, \quad 2\tau + 2g'.
 \end{aligned}$$

Annex 6.

Calculation of terms in δP , viz.

$$\begin{array}{l|l}
 -3 \sin 2\tau & \overbrace{-3 \cos g'}^{n^{-1}x} \\
 -\frac{21}{2} e' \text{ ,, } 2\tau - g' & -\frac{9}{4} e' \text{ ,, } 2g' \\
 +\frac{3}{2} e' \text{ ,, } 2\tau + g' &
 \end{array}$$

the product of which is

$$\begin{aligned}
 & 9 \left(\frac{1}{2} \sin 2\tau + g' + \frac{1}{2} \sin 2\tau - g' \right) \\
 & + \frac{63}{2} e' \left(\frac{1}{2} \text{ ,, } 2\tau + \frac{1}{2} \text{ ,, } 2\tau - 2g' \right) \\
 & - \frac{9}{2} e' \left(\frac{1}{2} \text{ ,, } 2\tau + 2g' + \frac{1}{2} \text{ ,, } 2\tau \right) \\
 & + \frac{27}{4} e' \left(\frac{1}{2} \text{ ,, } 2\tau + 2g' + \frac{1}{2} \text{ ,, } 2\tau - 2g' \right),
 \end{aligned}$$

which is =

$$\begin{aligned}
 & \left(\frac{63}{4} - \frac{9}{4} = \right) \cdot \overbrace{\frac{27}{2} e' \sin 2\tau}^{n^{-1}x} \\
 & + \frac{9}{2} \text{ ,, } 2\tau - g' \\
 & + \frac{9}{2} \text{ ,, } 2\tau + g' \\
 & \left(\frac{63}{4} + \frac{27}{8} = \right) + \frac{153}{8} e' \text{ ,, } 2\tau - 2g' \\
 & \left(-\frac{9}{4} + \frac{27}{8} = \right) + \frac{9}{8} e' \text{ ,, } 2\tau + 2g'.
 \end{aligned}$$

Annex 7.

Calculation of terms in δQ , viz.

$- 3 \quad \cos 2 \tau$	$\overbrace{- 3 \quad \cos g'}^{n^{-1} x}$
$-\frac{21}{2} e' \quad ,, \quad 2 \tau - g'$	$-\frac{9}{4} e' \quad ,, \quad 2 g';$
$+\frac{3}{2} e' \quad ,, \quad 2 \tau + g'$	

the product of which is

$$\begin{aligned}
 & 9 \left(\frac{1}{2} \cos 2 \tau - g' + \frac{1}{2} \cos 2 \tau + g' \right) \\
 & + \frac{63}{2} e' \left(\frac{1}{2} ,, 2 \tau - 2 g' + \frac{1}{2} ,, 2 \tau \right) \\
 & - \frac{9}{2} e' \left(\frac{1}{2} ,, 2 \tau + \frac{1}{2} ,, 2 \tau + 2 g' \right) \\
 & + \frac{27}{4} e' \left(\frac{1}{2} ,, 2 \tau - 2 g' + \frac{1}{2} ,, 2 \tau + 2 g' \right),
 \end{aligned}$$

which is =

$$\begin{aligned}
 & \left(\frac{63}{4} - \frac{9}{4} = \right) \overbrace{\frac{27}{2} e' \cos 2 \tau}^{n^{-1} x} \\
 & + \frac{9}{2} ,, 2 \tau - g' \\
 & + \frac{9}{2} ,, 2 \tau + g' \\
 & \left(\frac{63}{4} + \frac{27}{8} = \right) + \frac{155}{8} e' ,, 2 \tau - 2 g' \\
 & \left(-\frac{9}{4} + \frac{27}{8} = \right) + \frac{9}{8} e' ,, 2 \tau + 2 g'.
 \end{aligned}$$

Annex 8.

Calculation of $n \int \delta Q dt$.

We have

$$n \int \sin n \pi t dt = -\frac{1}{n} t \cos n \pi t + \frac{1}{n^2} \sin n \pi t,$$

$$\int \cos n \pi t dt = \frac{1}{n^2} \sin n \pi t,$$

and in all the arguments π is taken = 2.

$$\begin{array}{l|l} n \int \delta Q dt = -\frac{15}{4} \epsilon' t \cos 2 \tau & \left(+\frac{15}{8} + \frac{27}{4} = \right) + \overbrace{\frac{69}{8} \epsilon' \sin 2 \tau}^{n^{-1} \times} \\ +\frac{21}{8} \quad \text{,, } 2 \tau - g' & \left(-\frac{21}{16} + \frac{9}{4} = \right) + \frac{15}{16} \quad \text{,, } 2 \tau - g' \\ -\frac{3}{8} \quad \text{,, } 2 \tau + g' & \left(+\frac{3}{16} + \frac{9}{4} = \right) + \frac{39}{16} \quad \text{,, } 2 \tau + g' \\ +\frac{51}{4} \epsilon' \quad \text{,, } 2 \tau - 2g' & \left(-\frac{51}{8} + \frac{153}{16} = \right) + \frac{51}{16} \epsilon' \quad \text{,, } 2 \tau - 2g' \\ 0 \quad \text{,, } 2 \tau + 2g' & \left(0 + \frac{9}{16} = \right) + \frac{9}{16} \quad \text{,, } 2 \tau + 2g'. \end{array}$$

Annex 9.

Calculation of $\delta P + 2 n \int \delta Q dt$; viz. this is

$$\begin{array}{l|l} \frac{3}{2} \epsilon' t & \\ \frac{3}{2} t \cos g' & \\ \left(-\frac{15}{2} - \frac{15}{2} = \right) -15 \epsilon' \quad \text{,, } 2 \tau & \left(+\frac{27}{2} + \frac{69}{4} = \right) + \overbrace{\frac{123}{4} \epsilon' \sin 2 \tau}^{n^{-1} \times} \\ \left(+\frac{21}{4} + \frac{21}{4} = \right) + \frac{21}{2} \quad \text{,, } 2 \tau - g' & \left(+\frac{9}{2} + \frac{15}{8} = \right) + \frac{51}{8} \quad \text{,, } 2 \tau - g' \\ \left(-\frac{3}{4} - \frac{3}{4} = \right) -\frac{3}{2} \quad \text{,, } 2 \tau + g' & \left(+\frac{9}{2} + \frac{39}{8} = \right) + \frac{75}{8} \quad \text{,, } 2 \tau + g' \\ \left(+\frac{9}{2} + 0 = \right) + \frac{9}{2} \epsilon' \quad \text{,, } 2g' & \left(0 + 0 = \right) 0 \quad \text{,, } 2g' \\ \left(+\frac{51}{2} + \frac{51}{2} = \right) + 51 \epsilon' \quad \text{,, } 2 \tau - 2g' & \left(+\frac{153}{8} + \frac{51}{8} = \right) + \frac{51}{2} \epsilon' \quad \text{,, } 2 \tau - 2g' \\ \left(0 + 0 = \right) 0 \quad \text{,, } 2 \tau + 2g' & \left(+\frac{9}{8} + \frac{9}{8} = \right) + \frac{9}{4} \quad \text{,, } 2 \tau + 2g'. \end{array}$$

Annex 10.

Calculation of $\partial \epsilon$ from the equation

$$\frac{d^2 \partial \epsilon}{d t^2} + n^2 \partial \epsilon = m^2 n^2 \left(\partial P + 2n \int \partial Q dt \right).$$

In $\frac{d^2 \partial \epsilon}{d t^2} + n^2 \partial \epsilon$, a term $n^2 t \cos n \alpha t$, gives in $\partial \epsilon$,

$$\frac{1}{1-\alpha^2} t \cos n \alpha t + \frac{2\alpha}{(1-\alpha^2)^2} \frac{1}{n} \sin n \alpha t,$$

and a term $n \sin n \alpha t$, gives in $\partial \epsilon$,

$$\frac{1}{1-\alpha^2} \frac{1}{n} \sin n \alpha t.$$

and $\alpha = 2$, and $\therefore \frac{1}{1-\alpha^2} = -\frac{1}{3}$, for all the args.
except only $\alpha = m$ or $2m$, and $\therefore \frac{1}{1-\alpha^2} = 1$, for the args. g' , $2g'$.

$$\begin{aligned} \partial \epsilon = & \frac{3}{2} m^2 e' t & & \overbrace{\left(+ 3 \quad = \right)}^{n^{-1} \times} + \frac{1}{3} m^2 \sin g' \\ & + \frac{3}{2} m^2 t \cos g' & & \left(+ 3 \quad = \right) + \frac{1}{3} m^2 \sin g' \\ & + 5 m^2 e' \quad ,, \quad 2\tau & & \left(-\frac{20}{3} - \frac{41}{4} = \right) - \frac{203}{12} m^2 e' \quad ,, \quad 2\tau \\ & - \frac{7}{2} m^2 \quad ,, \quad 2\tau - g' & & \left(+ \frac{14}{3} - \frac{17}{8} = \right) + \frac{61}{24} m^2 \quad ,, \quad 2\tau - g' \\ & + \frac{1}{2} m^2 \quad ,, \quad 2\tau + g' & & \left(-\frac{2}{3} - \frac{25}{8} = \right) - \frac{91}{24} m^2 \quad ,, \quad 2\tau + g' \\ & + \frac{9}{2} m^2 e' \quad ,, \quad 2g' & & \left(+ 18 + 0 = \right) + 18 m^2 e' \quad ,, \quad 2g' \\ & - 17 m^2 e' \quad ,, \quad 2\tau - 2g' & & \left(+ \frac{68}{3} + \frac{17}{2} = \right) + \frac{85}{6} m^2 e' \quad ,, \quad 2\tau - 2g' \\ & 0 \quad ,, \quad 2\tau + 2g' & & \left(0 - \frac{3}{4} = \right) - \frac{3}{4} m^2 e' \quad ,, \quad 2\tau + 2g'. \end{aligned}$$

Annex 11.

Calculation of $\frac{d\delta v}{dt}$; viz. this is

$$= -2n\delta e + m^2 n^2 \int \delta Q dt.$$

$\frac{d\delta v}{dt} =$	$n \times$	
$\left(-3 \quad - \right) - 3 m^2 e' t$		
$\left(-3 \quad - \right) - 3 m^2 t \cos g'$		$\left(-6 \quad - \right) - 6 m^2 \sin g'$
$\left(-10 - \frac{15}{4} = \right) - \frac{55}{4} m^2 e' \quad ,, \quad 2e$		$\left(+ \frac{203}{6} + \frac{69}{8} = \right) + \frac{1019}{24} m^2 e' \quad ,, \quad 2e$
$\left(+7 + \frac{21}{8} = \right) + \frac{77}{8} m^2 \quad ,, \quad 2e - g'$		$\left(-\frac{61}{12} + \frac{15}{16} = \right) - \frac{199}{48} m^2 \quad ,, \quad 2e - g'$
$\left(-1 - \frac{3}{8} = \right) - \frac{11}{8} m^2 \quad ,, \quad 2e + g'$		$\left(+ \frac{91}{12} + \frac{39}{16} = \right) + \frac{481}{48} m^2 \quad ,, \quad 2e + g'$
$\left(-9 + 0 = \right) - 9 m^2 e' \quad ,, \quad 2g'$		$\left(-36 + 0 = \right) - 36 m^2 e' \quad ,, \quad 2g'$
$\left(+34 + \frac{51}{4} = \right) + \frac{187}{4} m^2 e' \quad ,, \quad 2e - 2g'$		$\left(-\frac{85}{3} + \frac{51}{16} = \right) - \frac{1207}{48} m^2 e' \quad ,, \quad 2e - 2g'$
$\left(0 + 0 \right) 0 \quad ,, \quad 2e + 2g'$		$\left(+ \frac{3}{2} + \frac{9}{16} = \right) + \frac{33}{16} m^2 e' \quad ,, \quad 2e + 2g'.$

Annex 12.

Calculation of δv from the foregoing value of $\frac{d\delta v}{dt}$.

We have

$$n \int \cos n\alpha t dt = \frac{1}{n} t \sin n\alpha t + \frac{1}{n^2 \alpha^2} \cos n\alpha t,$$

$$\int \sin n\alpha t dt = -\frac{1}{n\alpha} \cos n\alpha t;$$

$\alpha = 2$ for all the arguments, except only $\alpha = m, 2m$, for the arguments $g', 2g'$, respectively.

$$\begin{array}{lcl}
 \delta v = & & -\frac{3}{2} m^2 n' e' t^2 \\
 & & + \overbrace{n^{-1} x} \\
 - 3 m t \sin g' & \left(-\frac{3}{m^2} + 6 = \right) & - 3 + 6 m^2 \cos g' \\
 - \frac{55}{8} m^2 e' \quad ,, \quad 2\tau & \left(-\frac{55}{16} - \frac{1019}{48} = \right) & - \frac{74}{3} m^2 e' \quad ,, \quad 2\tau \\
 + \frac{77}{16} m^2 \quad ,, \quad 2\tau - g' & \left(+\frac{77}{32} + \frac{199}{96} = \right) & + \frac{215}{48} m^2 \quad ,, \quad 2\tau - g' \\
 - \frac{11}{16} m^2 \quad ,, \quad 2\tau + g' & \left(-\frac{11}{32} - \frac{481}{96} = \right) & - \frac{257}{48} m^2 \quad ,, \quad 2\tau + g' \\
 - \frac{9}{2} m e' \quad ,, \quad 2g' & \left(-\frac{9}{4m^2} + 18 = \right) & \left(-\frac{9}{4} + 18 m^2 \right) e' \quad ,, \quad 2g' \\
 + \frac{187}{8} m^2 e' \quad ,, \quad 2\tau - 2g' & \left(+\frac{187}{16} + \frac{1207}{96} = \right) & + \frac{2329}{96} m^2 e' \quad ,, \quad 2\tau - 2g' \\
 0 \quad ,, \quad 2\tau + 2g' & \left(0 - \frac{33}{32} = \right) & - \frac{33}{32} m^2 e' \quad ,, \quad 2\tau + 2g'.
 \end{array}$$

The remaining Annexes relate to the determination of the non-periodic or secular terms of the order m^4 , in δe and δv respectively.

Annex 13.

Calculation of term of $\left(n^2 + \frac{2n^2}{e^2} - 3 \left(\frac{dv}{dt} \right)^2 \right) \delta e$.

We have

$$\begin{array}{lcl}
 n^2 + \frac{2n^2}{e^2} - 3 \left(\frac{dv}{dt} \right)^2 = & \overbrace{n^2 x}^{n^2 \times} & \delta e = \\
 \left(1 + 2 + m^2 - 3 = \right) & m^2 & \frac{3}{2} m^2 e' t \\
 \left(-9 + 18 = \right) + 9 m^2 e' \cos g' & & + \frac{3}{2} m^2 t \cos g' \\
 \left(+6 - \frac{33}{2} = \right) - \frac{21}{2} m^2 \quad ,, \quad 2\tau & & + 5 m^2 e' \quad ,, \quad 2\tau \\
 \left(+21 - \frac{231}{4} = \right) - \frac{147}{4} m^2 e' \quad ,, \quad 2\tau - g' & & - \frac{7}{2} m^2 \quad ,, \quad 2\tau - g' \\
 \left(-3 + \frac{33}{4} = \right) + \frac{21}{4} m^2 e' \quad ,, \quad 2\tau + g' & & + \frac{1}{2} m^2 \quad ,, \quad 2\tau + g' \\
 & & + \&c.
 \end{array}$$

where, in the second factor, the arguments not occurring in the first factor are omitted, as not giving rise to any non-periodic

term; and so in other similar cases. Hence term of product is

$$\begin{aligned}
 m^4 n^2 e' t & \quad 1 \cdot \frac{3}{2} \\
 & + \frac{1}{2} \cdot 9 \cdot \frac{3}{2} \\
 & + \frac{1}{2} \cdot -\frac{21}{2} \cdot 5 \\
 & + \frac{1}{2} \cdot -\frac{147}{4} \cdot -\frac{7}{2} \\
 & + \frac{1}{2} \cdot \frac{21}{4} \cdot \frac{1}{2} \\
 & = \left(\frac{3}{2} + \frac{27}{4} - \frac{105}{4} + \frac{1029}{16} + \frac{21}{16} \right) + \frac{381}{8} m^4 n^2 e' t.
 \end{aligned}$$

Annex 14.

Calculation of term of $m^2 n^2 \delta P$.

$m^2 n^2 \delta P$, the part involving δv is

$\overbrace{m^2 n^2 \times}$	$\delta v =$
$-3 \sin 2\tau$	$-3 m t \sin g'$
$-\frac{21}{2} e' \text{ ,, } 2\tau - g'$	$-\frac{55}{8} m^2 e' \text{ ,, } 2\tau$
$+\frac{3}{2} e' \text{ ,, } 2\tau + g'$	$+\frac{77}{16} m^2 \text{ ,, } 2\tau - g'$
	$-\frac{11}{16} m^2 \text{ ,, } 2\tau + g'$
	$+ \&c.$

and term of the product is

$$\begin{aligned}
 m^4 n^2 e' t & \quad \frac{1}{2} \cdot -3 \cdot -\frac{55}{8} \\
 & + \frac{1}{2} \cdot -\frac{21}{2} \cdot \frac{77}{16} \\
 & + \frac{1}{2} \cdot \frac{3}{2} \cdot -\frac{11}{16} \\
 & = \left(\frac{165}{16} - \frac{1617}{64} - \frac{33}{64} \right) - \frac{495}{32} m^4 n^2 e' t.
 \end{aligned}$$

Annex 15.

Calculation of term of $m^2 n^2 \delta P$. $m^2 n^2 \delta P$, the term involving $\delta \epsilon$ is

$\overbrace{m^2 n^2 \times}$	$\delta \epsilon =$
$\frac{1}{2}$	$\frac{3}{2} m^2 \epsilon' t$
$+ \frac{3}{2} \epsilon' \cos g'$	$+ \frac{3}{2} m^2 t \cos g'$
$+ \frac{3}{2} \quad \text{,, } 2\tau$	$+ 5 m^2 \epsilon' \quad \text{,, } 2\tau$
$+ \frac{21}{4} \epsilon' \quad \text{,, } 2\tau - g'$	$- \frac{7}{2} m^2 \quad \text{,, } 2\tau - g'$
$- \frac{3}{4} \epsilon' \quad \text{,, } 2\tau + g'$	$+ \frac{1}{2} m^2 \quad \text{,, } 2\tau + g'$
	$+ \&c.$

and term of the product is

$$\begin{aligned}
 m^4 n^2 \epsilon' t & \quad \frac{1}{2} \cdot \frac{3}{2} \\
 & + \frac{1}{2} \cdot \frac{3}{2} \cdot \frac{3}{2} \\
 & + \frac{1}{2} \cdot \frac{3}{2} \cdot 5 \\
 & + \frac{1}{2} \cdot \frac{21}{4} \cdot -\frac{7}{2} \\
 & + \frac{1}{2} \cdot -\frac{3}{4} \cdot \frac{1}{2} \\
 & = \left(\frac{3}{4} + \frac{9}{8} + \frac{15}{4} - \frac{147}{16} - \frac{3}{16} \right) - \frac{15}{4} m^4 n^2 \epsilon' t.
 \end{aligned}$$

Annex 16.

Calculation of $\frac{\cos}{\sin} 2v - 2v'$, as far as m^3 .

$$\begin{aligned}\cos 2v - 2v' &= \cos 2\tau + X = \cos 2\tau \\ &\quad - X \sin 2\tau \\ &\quad - \frac{1}{2} X^2 \cos 2\tau, \\ \sin 2v - 2v' &= \sin 2\tau + X = \sin 2\tau \\ &\quad + X \cos 2\tau \\ &\quad - \frac{1}{2} X^2 \sin 2\tau,\end{aligned}$$

where

$$\begin{aligned}X &= -\left(4 + 6m\right) e' \sin g' \\ &\quad + \frac{11}{4} m^2 \quad \quad \quad \text{,, } 2\tau \\ &\quad + \frac{77}{8} m^2 e' \quad \quad \quad \text{,, } 2\tau - g' \\ &\quad - \frac{11}{8} m^2 e' \quad \quad \quad \text{,, } 2\tau + g',\end{aligned}$$

and thence

$$\begin{aligned}X \sin 2\tau &= -\left(4 + 6m\right) e' \left(\frac{1}{2} \cos 2\tau - g' - \frac{1}{2} \cos 2\tau + g'\right) \\ &\quad + \frac{11}{4} m^2 \left(\frac{1}{2} \quad \quad \quad - \frac{1}{2} \text{,, } 4\tau \right) \\ &\quad + \frac{77}{8} m^2 e' \left(\frac{1}{2} \cos g' \quad \quad \quad - \frac{1}{2} \text{,, } 4\tau - g'\right) \\ &\quad - \frac{11}{8} m^2 e' \left(\frac{1}{2} \text{,, } g' \quad \quad \quad - \frac{1}{2} \text{,, } 4\tau + g'\right),\end{aligned}$$

which is =

$$\begin{aligned}
 & \frac{11}{8} m^3 \\
 & \left(\frac{77}{16} - \frac{11}{16} = \right) + \frac{33}{8} m^2 e' \cos g' \\
 & - (2 + 3 m) e' \quad \text{,, } 2 \tau - g' \\
 & + (2 + 3 m) e' \quad \text{,, } 2 \tau + g' \\
 & - \frac{11}{8} m^3 \quad \text{,, } 4 \tau \\
 & - \frac{77}{16} m^2 e' \quad \text{,, } 4 \tau - g' \\
 & + \frac{11}{16} m^2 e' \quad \text{,, } 4 \tau + g';
 \end{aligned}$$

$$\begin{aligned}
 X \cos 2 \tau = & - (4 + 6 m) e' \left(\frac{1}{2} \sin 2 \tau + g' - \frac{1}{2} \sin 2 \tau - g' \right) \\
 & + \frac{11}{4} m^3 \left(\frac{1}{2} \text{,, } 4 \tau \right) \\
 & + \frac{77}{8} m^2 e' \left(\frac{1}{2} \text{,, } 4 \tau - g' - \frac{1}{2} \text{,, } g' \right) \\
 & - \frac{11}{8} m^2 e' \left(\frac{1}{2} \text{,, } 4 \tau + g' - \frac{1}{2} \text{,, } g' \right),
 \end{aligned}$$

which is =

$$\begin{aligned}
 & \left(-\frac{77}{16} - \frac{11}{16} = \right) - \frac{11}{2} m^2 e' \sin g' \\
 & + (2 + 3 m) e' \quad \text{,, } 2 \tau - g' \\
 & - (2 + 3 m) e' \quad \text{,, } 2 \tau + g' \\
 & + \frac{11}{8} m^3 \quad \text{,, } 4 \tau \\
 & + \frac{77}{16} m^2 e' \quad \text{,, } 4 \tau - g' \\
 & - \frac{11}{16} m^2 e' \quad \text{,, } 4 \tau + g';
 \end{aligned}$$

we have, moreover,

$$\begin{aligned} X^2 &= -2 \left(4 + 6m \right) e' \sin g' \cdot \frac{11}{4} m^2 \sin 2\tau \\ &= -22 m^2 e' \left(\frac{1}{2} \cos 2\tau - g' - \frac{1}{2} \cos 2\tau + g' \right) \\ &= -11 m^2 e' \cos 2\tau - g' \\ &\quad + 11 m^2 e' \quad ,, \quad 2\tau + g', \end{aligned}$$

and thence

$$\begin{aligned} X^2 \cos 2\tau &= -11 m^2 e' \left(\frac{1}{2} \cos 4\tau - g' + \frac{1}{2} \cos g' \right) \\ &\quad + 11 m^2 e' \left(\frac{1}{2} ,, \quad 4\tau + g' + \frac{1}{2} ,, \quad g' \right) \\ &= \left(-\frac{11}{2} + \frac{11}{2} = \right) 0 \quad \cos g' \\ &\quad - \frac{11}{2} m^2 e' \quad ,, \quad 4\tau - g' \\ &\quad + \frac{11}{2} m^2 e' \quad ,, \quad 4\tau + g'; \end{aligned}$$

and

$$\begin{aligned} X^2 \sin 2\tau &= -11 m^2 e' \left(\frac{1}{2} \sin 4\tau - g' + \frac{1}{2} \sin g' \right) \\ &\quad - 11 m^2 e' \left(\frac{1}{2} ,, \quad 4\tau + g' - \frac{1}{2} ,, \quad g' \right) \\ &= \left(-\frac{11}{2} - \frac{11}{2} = \right) -11 m^2 e' \sin g' \\ &\quad - \frac{11}{2} m^2 e' \quad ,, \quad 4\tau - g' \\ &\quad + \frac{11}{2} m^2 e' \quad ,, \quad 4\tau + g'; \end{aligned}$$

and thence

$$\begin{aligned}
 \cos 2\vartheta - 2\vartheta' = & -\frac{11}{8}m^2 \\
 & + 1 \quad \cos 2\varpi \\
 & - \frac{33}{8}m^2e' \quad ,, \quad g' \\
 & + (2+3m)e' \quad ,, \quad 2\varpi - g' \\
 & - (2+3m)e' \quad ,, \quad 2\varpi + g' \\
 & + \frac{11}{8}m^2 \quad ,, \quad 4\varpi \\
 & \left(+ \frac{77}{16} + \frac{11}{4} = \right) + \frac{121}{16}m^2e' \quad ,, \quad 4\varpi - g' \\
 & \left(- \frac{11}{16} - \frac{11}{4} = \right) - \frac{55}{16}m^2e' \quad ,, \quad 4\varpi + g';
 \end{aligned}$$

and

$$\begin{aligned}
 \sin 2\vartheta - 2\vartheta' = & 1 \quad \sin 2\varpi \\
 & \left(- \frac{11}{2} + \frac{11}{2} = \right) 0 \quad m^2e' \quad ,, \quad g' \\
 & + (2+3m)e' \quad ,, \quad 2\varpi - g' \\
 & - (2+3m)e' \quad ,, \quad 2\varpi + g' \\
 & + \frac{11}{8}m^2 \quad ,, \quad 4\varpi \\
 & \left(\frac{77}{16} + \frac{11}{4} = \right) + \frac{121}{16}m^2e' \quad ,, \quad 4\varpi - g' \\
 & \left(- \frac{11}{16} - \frac{11}{4} = \right) - \frac{55}{16}m^2e' \quad ,, \quad 4\varpi + g'.
 \end{aligned}$$

Annex 17.

Calculation of term in δQ .

The part of δQ containing δv is $\frac{\xi^2}{\xi^3} (-3 \cos 2v - 2v') \delta v$; and it is necessary to find in $\frac{\xi^2}{\xi^3} (-3 \cos 2v - 2v')$ the coefficient of $\cos g'$ as far as m^2 ; this is, in fact, required *post* Annex 21, for the calculation of $m^2 n^2 (C + \int \delta Q dt)$.

$\begin{aligned} \xi^2 &= 1 - \frac{1}{3} m^2 \\ &+ 3 m^2 e' \cos g' \\ &- 2 m^2 \quad \quad \quad \text{,, } 2\tau \\ &- 7 m^2 e' \quad \quad \quad \text{,, } 2\tau - g' \\ &+ 1 m^2 e' \quad \quad \quad \text{,, } 2\tau + g' \end{aligned}$	$\begin{aligned} \frac{1}{\xi^3} &= 1 \\ &+ 3 e' \cos g' \end{aligned}$
--	---

and thence

$\begin{aligned} \frac{\xi^2}{\xi^3} &= \\ &1 - \frac{1}{3} m^2 \\ &+ \left(3 + 2 m^2\right) e' \cos g' \\ &- 2 m^2 \quad \quad \quad \text{,, } 2\tau \\ &\left(-7 - \frac{1}{2} \cdot 2 \cdot 3\right) - 10 m^2 e' \quad \quad \quad \text{,, } 2\tau - g' \\ &\left(+1 - \frac{1}{2} \cdot 2 \cdot 3\right) - 2 m^2 e' \quad \quad \quad \text{,, } 2\tau + g' \end{aligned}$	$\begin{aligned} -3 \cos 2v - 2v' &= \\ &\frac{33}{8} m^2 \\ &+ \frac{99}{8} m^2 e' \cos g' \\ &- 3 \quad \quad \quad \text{,, } 2\tau \\ &- (6 + 9m) e' \quad \quad \quad \text{,, } 2\tau - g' \\ &+ (6 + 9m) e' \quad \quad \quad \text{,, } 2\tau + g' \\ &\&c. \end{aligned}$
--	--

where, in the second column, the omitted terms have arguments containing 4τ , and, consequently, do not, by combination with the first column, give rise to any term with the argument g' . The term *arg. g'* arises from the combinations

$$\begin{aligned}
& \frac{33}{8} m^2 \cdot 3 \epsilon' \cos g' \\
& + \frac{99}{8} m^2 \epsilon' \cdot 3 \quad \quad \quad \text{,, } g' \\
& - 3 \quad \cdot - 10 m^2 \epsilon' \left(\cos 2 \tau \cos 2 \tau - g' = \frac{1}{2} \cos 4 \tau - g' + \frac{1}{2} \cos g' \right) \\
& - 3 \quad \cdot - 2 m^2 \epsilon' \left(\text{,, } 2 \tau \quad \text{,, } 2 \tau + g' = \frac{1}{2} \text{,, } 4 \tau + g' + \frac{1}{2} \text{,, } g' \right) \\
& - 6 \epsilon' \cdot - 2 m^2 \left(\text{,, } 2 \tau \quad \text{,, } 2 \tau - g' = \frac{1}{2} \text{,, } 4 \tau - g' + \frac{1}{2} \text{,, } g' \right) \\
& + 6 \epsilon' \cdot - 2 m^2 \left(\text{,, } 2 \tau \quad \text{,, } 2 \tau + g' = \frac{1}{2} \text{,, } 4 \tau + g' + \frac{1}{2} \text{,, } g' \right)
\end{aligned}$$

so that the required term is

$$\left(\frac{99}{8} + \frac{99}{8} + 15 + 3 + 6 - 6 = \right) + \frac{171}{4} m^2 \epsilon' \cos g'.$$

and annexing this to the terms found Annex 2, the part of ∂Q which contains ∂v is

$ \begin{aligned} & \frac{171}{4} m^2 \epsilon' \cos g' \\ & - 3 \quad \quad \quad \text{,, } 2 \tau \\ & - \frac{21}{2} \epsilon' \quad \quad \quad \text{,, } 2 \tau - g' \\ & + \frac{3}{2} \epsilon' \quad \quad \quad \text{,, } 2 \tau + g' \end{aligned} $	$\partial v.$
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Annex 18.

Calculation of term of $m^2 n^2 \partial P$.

The part of ∂P involving $\partial v'$ and $\partial \epsilon$ is

$$\partial P = \epsilon \left[\left(\frac{1}{2} + \frac{3}{2} \cos 2 \nu - 2 \nu' \right) \partial_{\epsilon^2} \frac{1}{\epsilon^2} + \left(3 \sin 2 \nu - 2 \nu' \right) \frac{\partial \nu'}{\epsilon^2} \right];$$

$\xi =$	$\frac{1}{2} + \frac{3}{2} \cos 2\vartheta - 2\vartheta' =$	$3 \frac{1}{\xi^2} =$
$1 - \frac{1}{6} m^2$	$\frac{1}{2} - \frac{33}{16} m^2$	$3 e' t$
$+ \frac{3}{2} m^2 e' \cos g'$	$-\frac{99}{16} m^2 e' \cos g'$	$+ 3 t \cos 2 g'$
$- m^2 \quad , \quad 2\tau$	$+ \frac{3}{2} \quad , \quad 2\tau$	$+ 9 e' \quad , \quad 2 g'$
$-\frac{7}{2} m^2 e' \quad , \quad 2\tau - g'$	$+ \left(3 + \frac{9}{2} m\right) e' \quad , \quad 2\tau - g'$	
$+ \frac{1}{2} m^2 e' \quad , \quad 2\tau + g'$	$-\left(3 + \frac{9}{2} m\right) e' \quad , \quad 2\tau + g'$	
	$+ \&c.$	

where, in the second factor, the terms belonging to the arguments which contain 4τ (i.e. the arguments 4τ , $4\tau - g'$, $4\tau + g'$) are omitted. In fact, the terms in question would, in the product of the second and third factors, give rise to terms with arguments containing 4τ , and as there are no such terms in the first factor, there is no resulting secular term.

The product of the second and third factors is

$$\begin{aligned}
& \left(\frac{3}{2} - \frac{99}{16} m^2 \right) e' \quad t \\
& + \left(\frac{3}{2} - \frac{99}{16} m^2 \right) \quad t \cos g' \\
& + \frac{9}{2} e' \quad , , \quad 2 \tau \\
& - \frac{297}{16} m^2 e' \quad \left(\frac{1}{2} t \quad + \frac{1}{2} t \cos 2 g' \right) \\
& + \frac{9}{2} \quad \left(\frac{1}{2} t \cos 2 \tau - g' \quad + \frac{1}{2} \quad , , \quad 2 \tau + g' \right) \\
& + \left(9 + \frac{27}{2} m \right) e' \quad \left(\frac{1}{2} t \quad , , \quad 2 \tau - 2 g' \quad + \frac{1}{2} \quad , , \quad 2 \tau \right) \\
& - \left(9 + \frac{27}{2} m \right) e' \quad \left(\frac{1}{2} \quad , , \quad 2 \tau + 2 g' \quad + \frac{1}{2} \quad , , \quad 2 \tau \right) \\
& + \left(\frac{9}{2} - \frac{297}{16} m^2 \right) e' \quad t \cos 2 g' \\
& + \frac{27}{2} e' \quad \left(\frac{1}{2} t \cos 2 \tau - 2 g' \quad + \frac{1}{2} t \cos 2 \tau + 2 g' \right),
\end{aligned}$$

and we may in this product omit the terms with arguments containing $2g'$, since the first factor does not contain any such term. The product then is

$$\begin{aligned}
 & \left(-\frac{99}{16} - \frac{297}{32} = -\frac{495}{32} \right) \left(\frac{3}{2} - \frac{495}{32} m^2 \right) e' t \\
 & + \left(\frac{3}{2} - \frac{99}{16} m^2 \right) t \cos g' \\
 & \left(\left(\frac{9}{2} + \frac{9}{2} - \frac{9}{2} \right) e' + \left(\frac{27}{4} - \frac{27}{4} \right) m e' \right) + \frac{9}{2} e' \quad ,, \quad 2\tau \\
 & + \frac{9}{4} \quad ,, \quad 2\tau - g' \\
 & + \frac{9}{4} \quad ,, \quad 2\tau + g',
 \end{aligned}$$

which is to be multiplied by the first factor, e , and the whole by the factor $m^2 n^2$.

The term in the product is

$$\begin{aligned}
 m^2 n^2 e' t & \left(\frac{3}{2} - \frac{495}{32} m^2 \right) \left(1 - \frac{1}{6} m^2 \right) \\
 & + \frac{1}{2} \cdot \frac{3}{2} \quad . \quad \frac{3}{2} m^2 \\
 & + \frac{1}{2} \cdot \frac{9}{2} \quad . \quad - m^2 \\
 & + \frac{1}{2} \cdot \frac{9}{4} \quad . \quad - \frac{7}{2} m^2 \\
 & + \frac{1}{2} \cdot \frac{9}{4} \quad . \quad \frac{1}{2} m^2,
 \end{aligned}$$

giving the term $\frac{3}{2} m^2 n^2 e' t$, which was found above, Annex 9, and the new terms

$$\left(-\frac{495}{32} - \frac{1}{4} + \frac{9}{8} - \frac{9}{4} - \frac{63}{16} + \frac{9}{16} = \right) - \frac{647}{32} m^4 n^2 e' t.$$

The term of the part containing $\delta v'$ is found to be $= 0$;
In fact, we have

$\xi =$	$3 \sin 2 \vartheta - 2 \vartheta' =$	$\frac{\partial \vartheta'}{\xi^3} =$
$1 - \frac{1}{6} m^2$	$3 \sin 2 \vartheta$	$2 \quad \vartheta' \sin \vartheta'$
$+ \frac{3}{2} m^2 \vartheta' \cos \vartheta'$	$+ (6 + 9 m) \vartheta' \quad \text{,,} \quad 2 \vartheta - \vartheta'$	$+ \frac{11}{2} \vartheta' \quad \text{,,} \quad 2 \vartheta'$
$- m^2 \quad \text{,,} \quad 2 \vartheta$	$- (6 + 9 m) \vartheta' \quad \text{,,} \quad 2 \vartheta + \vartheta'$	
$-\frac{7}{2} m^2 \vartheta' \quad \text{,,} \quad 2 \vartheta - \vartheta'$	$\&c.$	
$+\frac{1}{2} m^2 \vartheta' \quad \text{,,} \quad 2 \vartheta + \vartheta'$		

where in the second factor the terms with arguments containing τ are for the before-mentioned reason omitted.

The product of the second and third factors is

$$\begin{aligned}
& 6 \left(\frac{1}{2} t \cos 2\tau - g' - \frac{1}{2} t \cos 2\tau + g' \right) \\
& + (12 + 18m) e' \left(\frac{1}{2} \text{ ,, } 2\tau - 2g' - \frac{1}{2} \text{ ,, } 2\tau \right) \\
& - (12 + 18m) e' \left(\frac{1}{2} \text{ ,, } 2\tau - \frac{1}{2} \text{ ,, } 2\tau + 2g' \right) \\
& + \frac{33}{2} e' \left(\frac{1}{2} \text{ ,, } 2\tau - 2g' - \frac{1}{2} \text{ ,, } 2\tau + 2g' \right)
\end{aligned}$$

which, omitting the terms with arguments containing $z q'$, is

$$\begin{aligned} -(6 + 9m + 6 + 9m) &= -(12 + 18m) e' t \cos 2\tau \\ &+ 3 \quad \text{,, } 2\tau - g' \\ &- 3 \quad \text{,, } 2\tau + g' \end{aligned}$$

which is to be multiplied by the first factor, e , and the whole by $m^2 n^2$. The term is

$$m^4 n^2 e^t \left(\frac{1}{2} - 12 - 1 \right. \\ \left. + \frac{1}{2} - 3 - \frac{7}{2} \right. \\ \left. + \frac{1}{2} - 3 - \frac{1}{2} \right)$$

which is

$$\left(6 - \frac{21}{4} - \frac{3}{4} - \right) \circ m^4 n^2 e' t.$$

Hence the entire term in question is the before-mentioned value

$$- \frac{647}{32} m^4 n^2 e' t.$$

Annex 19.

Calculation of term in $m^2 n^2 \frac{2}{e} \frac{dv}{dt} \left(C + \int^3 Q dt \right).$

We have

$$\frac{2}{e} \frac{dv}{dt} =$$

$$2 + \frac{n \times}{3} m^2$$

$$- 9 m^2 e' \cos g'$$

$$+ \frac{15}{2} m^2 \quad ,, \quad 2 \tau$$

$$+ \frac{105}{4} m^2 e' \quad ,, \quad 2 \tau - g'$$

$$- \frac{15}{4} m^2 e' \quad ,, \quad 2 \tau + g'$$

See *post* Annex 20.

$$m^2 n^2 \left(C + \int^3 Q dt \right) =$$

$$- \frac{n \times}{32} m^4 e' t$$

$$0 \quad t \cos g'$$

$$- \frac{15}{4} m^2 \quad ,, \quad 2 \tau$$

$$+ \frac{21}{8} m^2 \quad ,, \quad 2 \tau - g'^2$$

$$- \frac{3}{8} m^2 \quad ,, \quad 2 \tau + g'$$

For the term $- \frac{1455}{32} m^4 e' t$ see
post Annex 21.

The term in the product therefore is

$$m^4 n^2 e' t \quad 2 \quad - \frac{1455}{32}$$

$$+ \frac{1}{2} \cdot \frac{15}{2} \cdot - \frac{15}{4}$$

$$+ \frac{1}{2} \cdot \frac{105}{4} \cdot - \frac{21}{8}$$

$$+ \frac{1}{2} \cdot - \frac{15}{4} \cdot - \frac{3}{8}$$

which is

$$= \left(2 \cdot -\frac{1455}{32} - \frac{225}{16} + \frac{2205}{64} + \frac{45}{64} \right) m^4 n^3 e' t$$

$$= \left(2 \cdot -\frac{1455}{32} + \frac{675}{32} = \right) -\frac{2235}{32} m^4 n^3 e' t.$$

Annex 20.

Calculation of $\frac{2}{\epsilon} \frac{dv}{dt}$.

We have

$\frac{dv}{dt} =$	$\frac{2}{\epsilon} =$
$\overbrace{1}^{n \times}$	
$- 3 m^2 e' \cos g'$	$2 + \frac{1}{3} m^2$
$+ \frac{11}{4} m^2 e' \quad ,, \quad 2 \tau$	$- 3 m^2 e' \cos g'$
$+ \frac{77}{8} m^2 e' \quad ,, \quad 2 \tau - g'$	$+ 2 m^2 \quad ,, \quad 2 \tau$
$- \frac{11}{8} m^2 e' \quad ,, \quad 2 \tau + g'$	$+ 7 \tau^2 e' \quad ,, \quad 2 \tau - g'$
	$- 1 m^2 e' \quad ,, \quad 2 \tau + g'$

so that the product is

$$\overbrace{2 + \frac{1}{3} m^2}^{n \times}$$

$$\left(- 6 - 3 = \right) - 9 m^2 e' \cos g'$$

$$\left(+ \frac{11}{2} + 1 = \right) + \frac{15}{2} m^2 \quad ,, \quad 2 \tau$$

$$\left(+ \frac{77}{4} + 7 = \right) + \frac{105}{4} m^2 e' \quad ,, \quad 2 \tau - g'$$

$$\left(- \frac{11}{4} - 1 = \right) - \frac{15}{8} m^2 e' \quad ,, \quad 2 \tau + g'.$$

Annex 21.

Calculation of a term in $m^2 n^2 (C + \int \delta Q dt)$.

The part $\frac{\epsilon^2}{\epsilon^2} (-3 \sin 2v - 2v')$ $\delta \epsilon$ of δQ gives

$\frac{\epsilon^2}{\epsilon^2} (-3 \sin 2v - 2v') =$	$\delta \epsilon =$
	$\underbrace{\quad}_{\substack{n^{-1} \times \\ 3 \quad m^2 \quad \sin g'}}$
$- 3 \quad \sin 2v$	$-\frac{203}{12} m^2 \epsilon' \quad ,, \quad 2v$
$-\frac{21}{2} \epsilon' \quad ,, \quad 2v - g'$	$+\frac{61}{24} m^2 \quad ,, \quad 2v - g'$
$+\frac{3}{2} \epsilon' \quad ,, \quad 2v + g'$	$-\frac{91}{24} m^2 \quad ,, \quad 2v + g'$

and we have thence in $m^2 n^2 \delta Q$ the term

$$\begin{aligned}
 m^4 n \epsilon' & \quad \frac{1}{2} \cdot 3 \cdot -\frac{203}{12} \\
 & + \frac{1}{2} \cdot -\frac{21}{2} \cdot \frac{61}{24} \\
 & + \frac{1}{2} \cdot \frac{3}{2} \cdot -\frac{91}{24};
 \end{aligned}$$

that is

$$\left(\frac{203}{8} - \frac{427}{32} - \frac{91}{32} \right) + \frac{147}{16} m^4 n \epsilon'.$$

The part $\frac{\epsilon^2}{\epsilon^2} (3 \cos 2v - 2v')$ δv of δQ gives

$\frac{\epsilon^2}{\epsilon^2} (-3 \cos 2v - 2v') =$	$\delta v =$
	$\underbrace{\quad}_{\substack{n^{-1} \\ - 3 \quad \cos g'}}$
$\frac{171}{4} m^2 \epsilon' \cos g'$	
$- 3 \quad ,, \quad 2v$	$-\frac{74}{3} m^2 \epsilon' \quad ,, \quad 2v$
$-\frac{21}{2} \epsilon' \quad ,, \quad 2v - g'$	$+\frac{215}{48} m^2 \quad ,, \quad 2v - g'$
$+\frac{3}{2} \epsilon' \quad ,, \quad 2v + g'$	$-\frac{257}{48} m^2 \quad ,, \quad 2v + g'$

(*Ante*, Annex 17).

and we have thence in $m^2 n^2 \delta Q$ the term

$$m^4 n e' \left(\frac{1}{2} \cdot \frac{171}{4} \cdot -3 \right. \\ \left. + \frac{1}{2} \cdot -3 \cdot -\frac{74}{3} \right. \\ \left. + \frac{1}{2} \cdot -\frac{21}{2} \cdot \frac{215}{48} \right. \\ \left. + \frac{1}{2} \cdot \frac{3}{2} \cdot -\frac{257}{48} \right)$$

that is

$$\left(-\frac{513}{8} + 37 - \frac{1505}{64} - \frac{257}{64} \right) - \frac{1749}{32} m^4 n e';$$

and, combining this with the other term just obtained, the two together are

$$\left(\frac{147}{16} - \frac{1749}{32} \right) - \frac{1455}{32} m^4 n e';$$

and this term in $m^2 n^2 \delta Q$ gives in $m^2 n^2 (C + \int \delta Q dt)$ the term

$$-\frac{1455}{32} m^4 n e' t.$$

Annex 22.

Calculation of term in $-\frac{2}{e} \frac{dv}{dt} \delta e$.

We have

$-\frac{2}{e} \frac{dv}{dt} \text{ (see Annex 19) } =$ $\underbrace{-2 - \frac{1}{3} m^2}_{n \times}$ $+ 9 m^2 e' \cos g'$ $- \frac{15}{2} m^2 \quad ,, \quad 2 \tau$ $- \frac{105}{4} m^2 e' \quad ,, \quad 2 \tau - g'$ $+ \frac{15}{4} m^2 e' \quad ,, \quad 2 \tau + g'$	$e =$ $\left(\frac{3}{2} m^2 - \frac{1973}{32} m^4 \right) e' t$ $+ \frac{3}{2} m^2 \quad t \cos g'$ $+ 5 m^2 e' \quad ,, \quad 2 \tau$ $- \frac{7}{2} m^2 \quad ,, \quad 2 \tau - g'$ $+ \frac{1}{2} m^2 \quad ,, \quad 2 \tau + g'$
--	--

giving, besides the term $\frac{3}{2} m^2 n e' t$ already taken account of, the term

$$\begin{aligned}
 m^4 n e' t &+ \frac{1973}{16} \cdot -\frac{1}{3} \cdot \frac{3}{2} \\
 &+ \frac{1}{2} \cdot 9 \cdot \frac{3}{2} \\
 &+ \frac{1}{2} \cdot -\frac{15}{2} \cdot 5 \\
 &+ \frac{1}{2} \cdot -\frac{105}{4} \cdot -\frac{7}{2} \\
 &+ \frac{1}{2} \cdot \frac{15}{4} \cdot \frac{1}{2}
 \end{aligned}$$

which is

$$\begin{aligned}
 &= \left(\frac{1973}{16} - \frac{1}{2} + \frac{27}{4} - \frac{75}{4} + \frac{735}{16} - \frac{15}{16} \right) m^4 n^2 e' t \\
 &= \left(\frac{1973}{16} + \frac{275}{8} = \right) \frac{2^c 23}{16} m^4 n^2 e' t.
 \end{aligned}$$

Annex 23.

Calculation of term in $\frac{m^2 n^3}{e^2} (C + \int \delta Q dt)$.

We have

$$\frac{1}{e^2} =$$

$$\begin{aligned}
 &1 + \frac{1}{3} m^2 \\
 &- 3 m^2 e' \cos g' \\
 &+ 2 m^2 \quad ,, \quad 2 \tau \\
 &+ 7 m^2 e' \quad ,, \quad 2 \tau - g' \\
 &- 1 m^2 e' \quad ,, \quad 2 \tau + g'
 \end{aligned}$$

$$m^2 n^2 (C + \int \delta Q dt) =$$

$$\begin{aligned}
 &\underbrace{n \times}_{\frac{1455}{32} m^2 e' t} \\
 &- \frac{15}{4} m^2 e' t \cos 2 \tau \\
 &+ \frac{21}{8} m^2 e' \quad ,, \quad 2 \tau - g' \\
 &- \frac{3}{8} m^2 e' \quad ,, \quad 2 \tau + g'
 \end{aligned}$$

giving the term

$$\begin{aligned}
 m^4 n e' t &- \frac{1455}{32} \\
 &+ \frac{1}{2} \cdot 2 \cdot -\frac{15}{4} \\
 &+ \frac{1}{2} \cdot 7 \cdot \frac{21}{8} \\
 &+ \frac{1}{2} \cdot -1 \cdot -\frac{3}{8}
 \end{aligned}$$

which is

$$= \left(-\frac{1455}{32} - \frac{15}{4} + \frac{147}{16} + \frac{3}{16} \right) = \left(-\frac{1455}{32} + \frac{45}{8} = \right) -\frac{1275}{32} m^4 n e' t,$$

and this completes the series of calculations.

MONTHLY NOTICES
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Dr. LEE, President, in the Chair.

Rev. J. Morton, Clifton ;
J. F. Beckett, Esq., R.N. ;
Rev. E. K. Elliott, Broadwater ; and
N. Martindale, Esq., Holmfield, near Liverpool,
were balloted for and duly elected Fellows of the Society.

*On a Re-discovery of the missing Lunar Crater, Alhazen,
situated on the western border of the Mare Crisium.*
By W. R. Birt, Esq.

The Rev. T. W. Webb, in his interesting catalogue of lunar objects, speaks thus of this crater :—

“On the western edge of the *Mare Crisium*, Schröter delineated a crater, called by him *Alhazen*, which he employed to measure the existing libration: he saw in it, after a time, unaccountable changes; and now it is said it cannot be found. Beer and Mädler think he confounded it with a crater lying further south; the question, however, which in the interim was debated between Kunowsky and Köhler, is not quite cleared up.”

Having obtained a view, in January last, of *two* objects which appeared to me to have given rise to Schröter's remarks, I communicated my observations to Mr. Webb, and have lately received from that gentleman the following historical notices

of *Alhazen*, bearing especially on the variability of its aspect:—

"Schröter had watched and measured from it for years, and found it too varying in aspect to be accounted for by the varying angle of illumination. At first it was a depressed surface, surrounded by a ring, and distinguished from the neighbouring objects under all angles by its dark grey tint. Subsequently it often appeared, even in a 27-foot reflector (mirror about 20 inches), under favourable circumstances, as a bright longish flat mountain, though *more* frequently in its original grey aspect; occasionally it would be so indistinct, other objects being well defined, that he could not tell what to make of it. 1797, March 1, *Alhazen* being very near the limb (only 27" from it), and therefore in a position to be very indistinct, especially as the terminator had advanced to the other side of the *Mare*, he saw it with a 13-foot reflector (mirror about 9 inches and power 180) more distinctly than ever, and in quite a new form, as a real, very deep, and bright crater, with an irregular ring scarcely united to the south, and open to the north, with a projection on the east side. Also there was a small shadow, as of a crater never seen before during the innumerable observations of ten years. Schröter thought *Alhazen*, under this aspect, appeared as deep as *Proclus*."

Mr. Webb enclosed a tracing, with this remark:—"I think you will consider it as affording an interesting comparison with your own observations. He has figured, you will see (as well as described), a little crater where you describe 'two (?)'. The circumstance of his ranges uniting so closely to the south may be due to a different libration."

Kunowsky, in the *Astronomische Jahrbuch* for 1825, speaks of *Alhazen* as lost. In the *Jahrbuch* for 1826, Pastorff, writing January 20, 1823, says his son repeatedly found *Alhazen*. Pastorff also saw it (see p. 250 of the same *Jahrbuch*).

In the *Jahrbuch* for 1827 (p. 135), Harding is recorded as having seen *Alhazen* as Schröter had drawn it. Pastorff saw it in the same year, and in 1829.

The difference of aspect, as well as the occasional difficulty of finding this interesting spot, is highly curious. Schröter's earliest delineation gives it, as described, a shallow depression, *entirely* surrounded by a ring. My own observations, which now follow, may perhaps throw some light on these differences and difficulties. Two ranges of mountains, *one behind the other*, may easily be taken for a crater, and at a certain angle of illumination it may be exceedingly difficult to distinguish the difference. After a while the supposed crater entirely vanishes; libration alters the visual angle, and rotation the illuminating one, the observer being greatly puzzled as to what has become of his well-recognised crater.

1862, Jan. 3^d 4^h 45^m to 6^h 0^m, Moon's age 3^d.1, the termina-

tor passing through the *Mare Crisium* a little west of *Picard*, the floors of *Cleomedes*, *Burckhardt*, *Geminus*, and *Bernouilli* being in deep shadow, the *Promontorium Agarum* was very distinct, and in fine relief, and the craters *Condorcet*, *Hansen*, and *Alhazen* of Beer and Mädler exceedingly well marked; the *Alhazen* of Schröter also very distinct, and *Eimmart* between it and *Cleomedes* well seen.

Schröter's *Alhazen*, at first sight, appears to have somewhat the appearance of a crater, the west edge being high, but the east much lower. Upon attentively considering it, I have some reason to think that it consists of *two* nearly parallel ranges of mountains just on the borders of the *Mare*, the eastern range forming a part of the actual border. The shadow of the western range is (under this illumination) terminated at a line west of the eastern range, the western slope of which is glowing in bright sunshine. The mountain south of *Alhazen*, also figured by Schröter, is exceedingly distinct, and stands on the border of the *Mare*.

From the circumstance of not finding a distinct crater in this part of the border of the *Mare Crisium* when the evening shadows set in and the terminator sweeps over the western border of the *Mare*, combined with the surface of the *Mare* running in amongst the mountains on the west of the *Mare*, I am the more inclined to consider the appearance of a crater to be produced when the shadow of the western range falls short of the eastern.

1862, Jan. 4^d 5^h 30^m to 7^h 16^m, Moon's age 4^d.1, terminator obliquely through *Atlas*. *Oersted*, *Cepheus*, *Franklin*, and *Berzelius*, with *Promontorium Archideum*, form a fine chain between *Atlas* and *Geminus*.

At times the definition has been very fine, and the real character of Schröter's *Alhazen* well seen; the southern termination of the two mountain-ranges was seen to be quite separate the one from the other, and the level surface passing between them. It is not surprising that the two combined should have been regarded as a crater, especially if viewed by a low power; for now, haze coming on, it is impossible to distinguish the two from a crater. In the earlier part of the evening the independence of the two ranges, especially on the south, was very apparent: the *shorter* shadow brought out very distinctly the *mountain* character, and the recess of the shadow of the eastern range revealed the existence of two (?) small craters lying at the foot of the eastern slope, upon the very border of the *Mare Crisium*. Beer and Mädler figure two mountain-ranges in the locality, but very unlike the mountain-ranges described above.

Note on a dark, circular Spot upon the Sun's Disk, with rapid motion, as observed by W. Lummis, Esq., of Manchester, 1862, March 20. By J. R. Hind, Esq.

In a letter addressed to me on the 20th of March, by W. Lummis, Esq., of the Manchester, Sheffield, and Lincolnshire Railway Company's Office at Manchester, it was stated that on the morning of the same day, while examining the Sun's disk with a telescope of about $2\frac{1}{2}$ inches aperture, he had remarked a small black spot more regular and better defined than usual. He watched it about 20 minutes, during which time it had moved rapidly, as shown in a diagram accompanying his letter, maintaining its *round* form: Mr. Lummis called a friend to see it, who remarked it as distinctly as himself.

On applying for further information with reference to his observation, Mr. Lummis wrote me, "As to the positions of the spot I regret that I cannot give them with much more precision than shown in the rough sketch sent to you, which was taken from one made at the time I witnessed the transit. I had no instrument but the telescope, and I measured with a small strip of card the distances of the spot from the Sun's edge. From the time when I first observed it, 8^h 28^m A.M., (Manchester time) to 8^h 50^m, the spot had moved over about 12' of arc, as nearly as I can judge by the eye, and its size or rather apparent diameter I should take to be about 7". The telescope is $2\frac{1}{2}$ inches in aperture and magnifies 80 times. I had for several mornings been observing the Sun, which I noticed was particularly free from spots. Only one small one could be detected by me on the morning of the 20th, just below the spot marked A on the sketch.* I regret extremely having been compelled to leave before the object had completed its transit, as I should have wished to have witnessed its egress."

On carefully reading off from Mr. Lummis's sketch the differences of azimuth and altitude of the spot and Sun's centre, and converting them into differences of longitude and latitude, I find the following numbers,

G.M.T.	{ Longitude of spot = Long. of $\odot$ - 2'4
March 19 20 ^h 37 ^m	{ Latitude of spot = + 3'9
" 20 ^h 59 ^m	{ Longitude of spot = Long. of $\odot$ - 7'0
	{ Latitude of spot = + 5'5

It is evident, from the sketch, that Mr. Lummis's estimate of the arc passed over during the twenty-two minutes he watched the spot, is much too great. It would be nearer 6' than 12'.

In a letter dated 2d May, addressed to the Editor, Mr. Lummis writes that the spot appeared quite circular, and perfectly and sharply defined, and that the dimensions stated (*viz.* 7") may be regarded as a maximum measurement.

* The first position of the moving spot.

Considerations on the Solar Spots. By M. Eugene
Jeanjaquet.

The author refers to his work, *Phénomènes Célestes résultant de la Transmission successive de la Lumière*, published in 1859, as containing the following evident proof that the solar spots, whatever their nature may be, are not the appearances (*les aperçus*) of an obscure nucleus, situate in the centre of the photosphere, and consequently that there is no reason for believing in the existence of such a nucleus. "Si le soleil," he said, "était composé tout à la fois d'une noyau solide et d'une triple enveloppe gazeuse concentrique à ce noyau, si mince que fût cette enveloppe elle n'en augmenterait pas moins l'astre de son épaisseur; il y aurait par conséquent sur tout le pourtour du disque une bande circulaire sur laquelle aucune tache ne pourrait se montrer; en d'autres termes, ce n'est qu'à une certaine distance, en dedans du disque, que des taches pourraient se laisser voir. Or, les taches commencent et finissent avec les bords mêmes du soleil; donc elles ne sont pas des ouvertures dans le sein de l'atmosphère vraie ou fausse de l'astre de jour."

And, after illustrating this proof by a figure, he proceeds as follows:—

"Mais les taches solaires commencent-elles et finissent-elles réellement sur les bords de l'astre radieux? Il semble, tant la chose est suffisamment établie, que je pourrais me dispenser de faire cette question. Il s'en faut de beaucoup cependant que je ne doive pas la soulever. Suivant quelques observateurs, l'enveloppe solaire, dans l'hypothèse du globe central obscur, est excessivement peu épaisse; elle n'aurait de profondeur, d'après M. Secchi, que dans la minime proportion de quatre millimètres sur un globe d'un mètre de rayon.* Il est vrai de dire que M. Secchi, tout en faisant l'enveloppe solaire si mince, ne prétend pas imposer de tous points sa manière de voir. Il déclare lui-même que son opinion n'a rien d'absolu, puisqu'elle est le résultat d'une seule observation, et qu'il existe probablement des ouvertures plus profondes que celle qui lui a servi de mesure. Quoiqu'il en soit, l'enveloppe aurait dans tous les cas très-peu d'épaisseur. Or, une aussi mince enveloppe, si elle existe, réporterait naturellement les taches très-près des bords du soleil, si près même de ces bords que leur lieu d'apparition et de disparition ne pourrait souvent être constaté qu'avec la plus grande peine; partant, que l'on n'aurait absolument aucune assurance qu'un globe solide ne se trouvât pas en définitive au centre de l'astre du jour. La question de savoir si véritablement les taches naissent et s'effacent sur les bords du soleil est donc discutable, et elle mérite certainement d'être discutée.

* *Astronomische Nachrichten*, No. 1148, p. 307.

“Puis, il y a une autre question, se rattachant à l'existence des taches aux extrémités du disque solaire, qui mérite aussi d'être étudiée: Des entailles ont été vues occasionnellement sur le limbe du soleil, et ces entailles n'ont pas tardé à être suivies de taches. Est-ce que de semblables faits n'impliquent pas nécessairement des ouvertures dans une enveloppe, et au fond de ces ouvertures le corps intérieur de l'astre radieux ?

“Je m'empresse de le dire ; en ce qui touche la mince enveloppe du soleil, assez d'apparitions et de disparitions de taches ont été constatées pour qu'il ne puisse pas y avoir de doute sur le lieu où ces apparitions et disparitions s'opèrent. Ceux qui, depuis Galilée jusqu'à nos jours, ont longuement et patiemment examiné le soleil pour déduire du mouvement de ses taches le temps de sa rotation, ne nous auraient point donné le temps de cette rotation s'ils n'avaient pas vu des taches naître et mourir aux bords mêmes de l'astre lumineux. On ne lit dans les écrits d'aucun observateur que les taches commencent et finissent en dedans du limbe solaire, tandis qu'il n'est pas un auteur un peu compétent qui n'enseigne qu'elles apparaissent et disparaissent sur les bords mêmes de l'astre. Toutes nos connaissances sur le mouvement des taches seraient vaines, si les instants d'apparition et de disparition de ces étranges figures, aux limites extrêmes du soleil, ne nous étaient pas parfaitement connus. Que de choses, en revanche, ne saurions-nous pas sur le prétendu globe obscur, sur sa grandeur, sa distance à l'astre de lumière, etc. etc., si toutes les taches commençaient et finissaient en dedans du disque, à une distance des bords régulièrement la même ! Nous ne savons pas ces choses, du moins nous ne les savons pas comme nous devrions les savoir ; les taches ne se lèvent ni ne se couchent donc point, pour ainsi parler, à l'intérieur du disque solaire. Ainsi, on peut-être parfaitement tranquille, les taches apparaissent bien au bord oriental du soleil, et elles disparaissent bien à son bord occidental ; rien n'est plus certaine que ce fait-là.

“Au surplus, des taches naîtraient et mourraient régulièrement à une certaine distance en dedans du disque du soleil (ce que les observations n'indiquent point, mais que j'admets ici un instant par voie de supposition), des taches, dis-je, naîtraient et mourraient régulièrement en dedans du disque solaire, à une courte distance des bords, que même une semblable circonstance, à moins que les taches ne fussent grandes, fortes, bien distinctes, ne serait nullement conclusive de l'hypothèse du globe central obscur, puis qu'on pourrait toujours objecter que les taches disparaissent par l'effet de l'éloignement : ne sait-on pas combien les noyaux se rapetissent à mesure qu'ils s'éloignent du centre du soleil, combien ils grandissent au contraire à mesure qu'ils s'approchent de ce centre ?

“J'arrive aux entailles qui se voient occasionnellement sur les bords du soleil et qui ne sont naturellement autre chose que de fort grandes taches, tout noyau sur le limbe solaire y pro-

duisant nécessairement une échancrure. Si ces entailles se montrent en noir, on comprend que mon opinion s'en trouve fortifiée; et c'est bien en noir qu'elles se montrent. Mais il paraît qu'il y a à cette règle des exceptions et qu'en de certaines occasions, excessivement rares d'ailleurs, des entailles ont été vues béantes; c'est du moins ce qui semble surtout ressortir d'une grande échancrure que M. Lawson a observée le 30 Juin, 1846, sur le bord oriental du soleil, échancrure à laquelle une tache noire n'aurait pas tardé de faire suite. Une entaille béante suivie immédiatement d'une tache! Une ouverture photosphérique avec un noyau à sa base! Quelle plus grande preuve pourrait-on donner de l'existence d'un globe central obscur! Heureusement que pour répondre à cette formidable objection, nous avons l'exemple de la lune dans les éclipses de soleil. La lune aussi lorsqu'elle échancre le soleil, fait sur lui une entaille libre, et ce n'est jamais que lorsqu'elle le recouvre en entier qu'elle se révèle en *noir*: pourquoi un noyau de tache, s'avancant sur l'astre de lumière, ne se conduirait-il pas, toutes proportions gardées, de la même façon que notre satellite?* Ainsi, bien loin qu'une entaille béante indique une ouverture sur le bord de l'astre, on peut dire qu'une semblable échancrure est une preuve de plus de l'existence des taches aux extrêmes limites du disque du soleil."

"*Neuchâtel (Suisse)*, le 28-30 Mars 1862."

On the Transit of Mercury of 12 Nov. 1861, observed at Hobart Town. By Mr. Abbott.

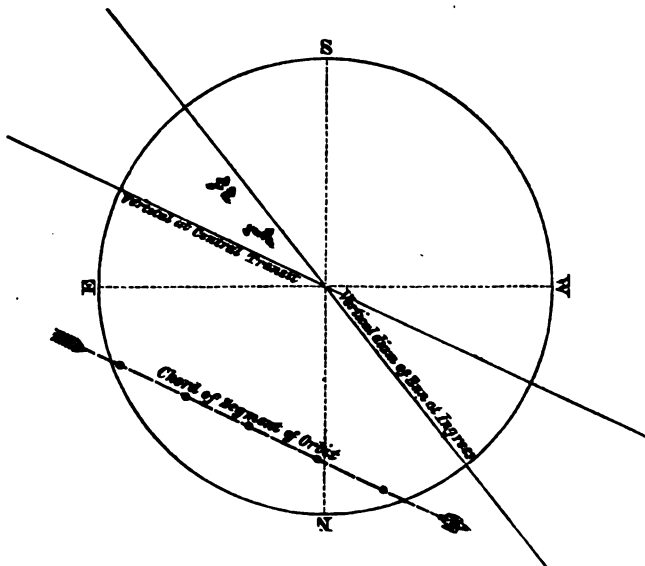
I transmit a diagram of the transit of *Mercury*, which occurred on the 12th of the present month. The time of ingress stated may not be quite as correct as I could have wished, from the following circumstances,—

To make sure of true time I had taken a transit at noon on the same day; on that point, therefore, I considered myself well prepared for the occasion.

A short time before the immersion, I had erected a 5-foot telescope on one of Varley's stands, and at the very point of the planet's contact, one of the bands gave way, which caused at that critical moment a slight confusion, until I could get the telescope tube remounted on a fresh stand; notwithstanding this accident I consider the time given a close approximation.

* "On n'a pas suffisamment fait attention, à mon avis, à tout ce qu'il y a de remarquable dans cette manière d'agir de la lune, parfaitement *invisible* tant qu'il reste une parcelle de lumière solaire, et, une fois le dernier filet de lumière supprimé, se montrant immédiatement en *noir*."

The afternoon on the whole was favourable, and had it not been for Mount Wellington (4240 feet high) blocking out our western horizon, the whole transit might have been seen, from ingress to egress.



Observed time of ingress for Hobart Town Mean Time.

	h	m	s
Exterior contact.....	3	6	16 P.M.
Centre	3	8	25 "
Interior contact	3	9	36 "

Hobart Town, Tasmania, Nov. 25, 1861.

Results of Meridional Observations of Small Planets; Occultations of a Star by the Moon; and Phenomena of Jupiter's Satellites; observed at the Royal Observatory, Greenwich, during the month of March, 1862.

(Communicated by the Astronomer Royal.)

Flora ⑧.

Mean Solar Time of Observation.	R.A. from Observation.	N.P.D. from Observation.
h m s	h m s	° ' "
1862, Mar. 25 13 57 22.8	14 10 25.49	93 17 42.46

Metis (9).

Mean Solar Time of Observation.			R.A. from Observation.	N.P.D. from Observation.
	^h	^m ^s	^h ^m ^s	[°] ['] ^{''}
1862, Mar. 4	9	40 33.9	8 30 6.85	62 15 40.00
8	9	23 47.4	8 29 3.77	62 20 57.70
10	9	15 37.0	8 28 45.12	62 24 38.50
12	9	7 34.6	8 28 34.57	62 28 50.88

Eunomia (15).

Mean Solar Time of Observation.			R.A. from Observation.	N.P.D. from Observation.
	^h	^m ^s	^h ^m ^s	[°] ['] ^{''}
1862, Mar. 4	9	16 54.2	8 6 23.29	76 1 7.76
12	8	43 34.1	8 4 30.11	76 6 16.08

Psyche (10).

Mean Solar Time of Observation.			R.A. from Observation.	N.P.D. from Observation.
	^h	^m ^s	^h ^m ^s	[°] ['] ^{''}
1862, Mar. 3	11	22 0.5	10 7 53.58	78 12 20.13
4	11	17 19.9	10 7 8.72	78 7 30.69

Thalia (28).

Mean Solar Time of Observation.			R.A. from Observation.	N.P.D. from Observation.
	^h	^m ^s	^h ^m ^s	[°] ['] ^{''}
1862, Mar. 3	11	50 45.8	10 36 43.55	60 38 39.90
4	11	45 56.7	10 35 50.27	60 36 48.56

Amphitrite (30).

Mean Solar Time of Observation.			R.A. from Observation.	N.P.D. from Observation.
	^h	^m ^s	^h ^m ^s	[°] ['] ^{''}
1862, Mar. 3	13	19 15.0	12 5 27.33	90 15 3.66
25	11	32 37.2	11 45 16.15	88 58 46.20

All the observations of N.P.D. have been corrected for Refraction and Parallax.

March 9. The disappearance of 6 *Geminorum* at the Moon's dark limb was observed by Mr. Criswick to take place at 7^h 1^m 40^s.6 mean solar time.

Phenomena of Jupiter's Satellites.

Day of Observation.	Satellite.	Phenomenon.	Mean Solar Time.	Observer.
1862.			h m s	
Mar. 4	III	Ecl. disapp.	14 38 34.5	T. C.
25	I	Egress, first cont.	8 38 41.9	C.
25	I	„ bisection	8 40 11.6	C.
25	I	„ last cont.	8 42 11.3	C.

The initials C. and T. C., are those of Mr. Criswick and Mr. Chappell.

Observations of Encke's Comet, taken with the Equatoreal of the Liverpool Observatory. By J. Hartnup, Esq.

Day.	G.M.T.			Comet's R.A.			N.P.D.	Stars of Comparison.
	h	m	s	h	m	s		
1861, Dec. 1	7	20	17.0	22	25	2.79	83 21 1.3	ζ Pegasi.
5	7	4	3.9	22	22	32.99	83 57 41.8	„
21	7	11	28.5	22	18	3.45	85 49 6.7	α Aquarii.
25	6	9	34.7	22	17	47.26	86 11 47.3	„
28	6	4	37.2	22	17	38.68	86 28 50.7	„
1862, Jan. 22	6	8	56.6	21	57	27.29	92 32 37.2	θ and α Aquarii.
25	6	8	5.2	21	47	20.09	94 45 10.4	α Aquarii.

The observations are corrected for Refraction and Parallax.

The places of the stars of comparison were taken from the *Nautical Almanac*.

On Lambert's Theorem for Elliptic Motion. By A. Cayley, Esq.

The theorem referred to is that which gives the time of description of an elliptic arc in terms of the radius vectors and the chord. The demonstration given by the author in his "Insigniores Orbitæ Cometarum Proprietates," Augs. 1761, depends upon a series of geometrical propositions of great elegance, which may be thus stated,

Let FQ be a line given in magnitude and position, E a given point on this line, Qf a line given in magnitude only, the position thereof being determined by assigning a value to

the direction from F to Q, the ellipse reduces itself to a finite right line, length F Q + Q f, which is considered to be described by a body falling from the extremity with an initial velocity zero; and the arc M N is a portion thereof given in magnitude, and having for its centre the point H (where E H is the diameter of the before-mentioned circle, the locus of G). Hence the time of describing the elliptic arc is equal to the time of describing, under the action of the same central force, a given right line, and as such it is at once obtainable in the form

$$\frac{a^{\frac{3}{2}}}{\sqrt{\mu}} (\phi - \phi' - (\sin \phi - \sin \phi'))$$

where ϕ, ϕ' are functions of the major axis F Q + Q f, and of F M, F N, or, what is the same thing, of F Q + Q f, and of the chord M N and sum of the radius vectors F M, F N. The preceding is the geometrical mode of getting out the result, without the assistance of any expression for the elliptic area, and latus rectum, and assuming only that we know the formula for rectilinear motion; but, if the expressions for the elliptic area and latus rectum are obtained, then the expression for the time is known, and the problem is solved, without the necessity of passing from the ellipse to the right line.

Writing F Q = ϵ , Q F = σ , and as before the exterior angle of inclination = 2θ , the actual expressions for the various lines of the figure are easily found to be

$$\begin{aligned} \frac{1}{2} (\epsilon + \sigma) & , = a \\ CF = Cf &= \frac{1}{2} \sqrt{\epsilon^2 + \sigma^2 + 2\epsilon\sigma \cos 2\theta} , = a \\ CQ &= \frac{1}{2} \sqrt{\epsilon^2 + \sigma^2 - 2\epsilon\sigma \cos 2\theta} , (= a' \\ CR &= \sqrt{\epsilon\sigma} , (= b' \end{aligned}$$

where C R (not shown in the figure) denotes the semi-diameter conjugate to C Q.

$$\begin{aligned} 1 - e^2 &= \frac{4\epsilon\sigma}{(\epsilon + \sigma)^2} \sin^2 \theta \\ \cos F &= \frac{\epsilon + \sigma \cos 2\theta}{2a\epsilon} , \cos Q = \frac{\epsilon - \sigma \cos 2\theta}{2a'} , \\ \sin F &= \frac{\sigma \sin 2\theta}{2a\epsilon} , \sin Q = \frac{\epsilon \sin 2\theta}{2a'} , \sin C = \frac{\epsilon\sigma \sin 2\theta}{4a'a\epsilon} , \end{aligned}$$

where F, C, Q , denote the angles of the triangle FCQ , respectively,

$$EG = \frac{2k\sigma}{\epsilon + \sigma} \cos \theta, \quad \text{and } \therefore EH = \frac{2k\sigma}{\epsilon + \sigma},$$

$$QG = \frac{k}{\epsilon + \sigma} 2\sigma',$$

and, if for shortness $\Lambda = \sqrt{k\epsilon\sigma(\epsilon + \sigma - k)}$, then

$$(EM, EN) = \frac{2}{\epsilon + \sigma} (\Lambda \pm k\sigma \cos \theta),$$

$$(FM, FN) = \frac{1}{\epsilon + \sigma} \{ \epsilon(\sigma + \epsilon) + k(\sigma - \epsilon) \pm 2\Lambda \cos \theta \},$$

so that

$$GM - GN = \frac{1}{2} (EM + EN) = \frac{2\Lambda}{\epsilon + \sigma},$$

$$\frac{1}{2} (FM + FN) = \frac{1}{\epsilon + \sigma} \{ \epsilon(\sigma + \epsilon) + k(\sigma - \epsilon) \},$$

and moreover

$$(e \cos u, e \cos u') = \frac{1}{(\epsilon + \sigma)^2} \{ (\sigma - \epsilon)(\epsilon + \sigma - 2k) \mp 4\Lambda \cos \theta \},$$

$$(e \sin u, e \sin u') = \frac{1}{(\epsilon + \sigma)^2} \left\{ \pm \frac{2(\sigma - \epsilon)\Lambda}{\sqrt{\epsilon\sigma}} + 2(\epsilon + \sigma - 2k) \sqrt{\epsilon\sigma} \cos \theta \right\},$$

so that

$$e \cos u + e \cos u' = \frac{2}{(\epsilon + \sigma)^2} (\epsilon + \sigma - 2k),$$

$$e \sin u - e \sin u' = \frac{4}{(\epsilon + \sigma)^2} \frac{(\sigma - \epsilon)\Lambda}{\sqrt{\epsilon\sigma}},$$

$$u - u' = 2 \tan^{-1} \frac{2\Lambda}{\sqrt{\epsilon\sigma}(\epsilon + \sigma - 2k)} = \sin^{-1} \frac{4\Lambda(\epsilon + \sigma - 2k)}{(\epsilon + \sigma)^2 \sqrt{\epsilon\sigma}},$$

$$u - u' - (e \sin u - e \sin u') = \sin^{-1} \frac{4(\epsilon + \sigma - 2k)\Lambda}{(\epsilon + \sigma)^2 \sqrt{\epsilon\sigma}} - \frac{4(\sigma - \epsilon)\Lambda}{(\epsilon + \sigma)^2 \sqrt{\epsilon\sigma}}$$

which is

$$= \phi - \phi' - (\sin \phi - \sin \phi'),$$

if

$$1 - \cos \phi = \frac{1}{2a} (FM + FM + MN) = \frac{2}{(\xi + \sigma)^2} \{ \xi(\sigma + \xi) + k(\sigma - \xi) + 2\Lambda \},$$

$$1 - \cos \phi' = \frac{1}{2a} (FM + FN - MN) = \frac{2}{(\xi + \sigma)^2} \{ \xi(\sigma + \xi) + k(\sigma - \xi) - 2\Lambda \}.$$

In fact we then have also

$$1 + \cos \phi = \frac{2}{(\xi + \sigma)^2} \{ \sigma(\sigma + \xi) - k(\sigma - \xi) - 2\Lambda \},$$

$$1 + \cos \phi' = \frac{2}{(\xi + \sigma)^2} \{ \sigma(\sigma + \xi) - k(\sigma - \xi) + 2\Lambda \},$$

and thence

$$\sin \frac{1}{2} \phi = \frac{1}{\xi + \sigma} (\sqrt{\xi(\xi + \sigma - k)} + \sqrt{k\sigma}), \quad \sin \frac{1}{2} \phi' = (\sqrt{\xi(\xi + \sigma - k)} - \sqrt{k\sigma}),$$

$$\cos \frac{1}{2} \phi = \frac{1}{\xi + \sigma} (\sqrt{\sigma(\xi + \sigma - k)} - \sqrt{k\xi}), \quad \cos \frac{1}{2} \phi' = (\sqrt{\sigma(\xi + \sigma - k)} + \sqrt{k\xi}),$$

whence

$$\sin \phi = \frac{2}{(\xi + \sigma)^2} \left\{ \sqrt{\xi\sigma} (\xi + \sigma - 2k) + \frac{(\sigma - \xi) \sqrt{\Lambda}}{\sqrt{\xi\sigma}} \right\},$$

$$\sin \phi' = \frac{2}{(\xi + \sigma)^2} \left\{ \sqrt{\xi\sigma} (\xi + \sigma - 2k) - \frac{(\sigma - \xi) \sqrt{\Lambda}}{\sqrt{\xi\sigma}} \right\},$$

$$\text{and } \therefore \sin \phi - \sin \phi' = \frac{4(\sigma - \xi) \sqrt{\Lambda}}{(\xi + \sigma)^2 \sqrt{\xi\sigma}},$$

$$\sin \frac{1}{2} (\phi - \phi') = \frac{2k\Lambda}{(\xi + \sigma) \sqrt{\xi\sigma}}, \quad \cos \frac{1}{2} (\phi - \phi') = \frac{\xi + \sigma - 2k}{\xi + \sigma},$$

$$\text{and } \therefore \sin (\phi - \phi') = \frac{4(\xi + \sigma - 2k) \Lambda}{(\xi + \sigma)^2 \sqrt{\xi\sigma}},$$

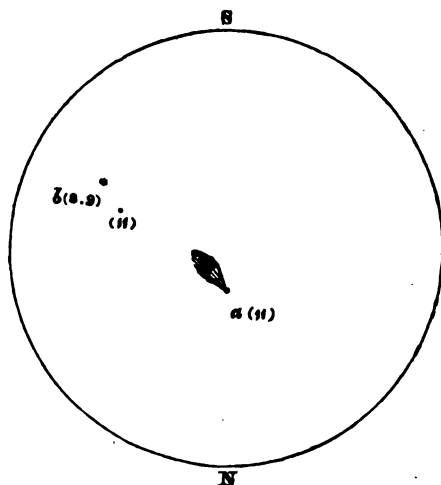
which verifies the formula.

On the missing Nebula in Taurus, on Comet II. 1861, and on Mountain Attractions. By M. O. Struve.

(Communicated by the Astronomer Royal.)

In the month of December we were informed by letters of Prof. d'Arrest's important observation, that the Nebula dis-

covered by Mr. Hind in the constellation of *Taurus* had disappeared. In the first favourable night, 1861, Dec. 29, we directed our large refractor upon the object, and in the first moment thought that its faintness exceeded even the power of our instrument; but, after some minutes, when the eyes had sufficiently adapted themselves to the darkness, we distinctly recognised some traces of nebulosity to the south of a star of 11th magnitude. Mr. Winnecke, whose assistance I had asked on this occasion, agreed with me entirely about the position of this nebulosity. The line joining it with the star of 11th magnitude made an angle of 15° f.f. with the line drawn from that star to another star of 11th magnitude, visible in the same field at a distance of 4' south preceding. The distances of the brightest part of the Nebula from the first-mentioned star was estimated by me = 0.22 , by Dr. Winnecke = 0.15 of the distance of the two stars, or about $50''$. Since then we had for nearly three months' very unfavourable weather, and it was only in the night of March 22 that I thought there was a good opportunity for inspecting again that object. My expectation was not deceived. On the first glimpse the Nebula appeared considerably brighter than it did in December, so that it even bore a feeble illumination of the wires. On measuring the direction from the star α (see accompanying sketch), I found it $213^\circ.2$, while that of the star b , mag. 8.9, was $221^\circ.6$.



As the other small star which had served for comparison on Dec. 29, has nearly the same direction as b , this observation

confirms perfectly the estimation made on that former occasion. On March 22 I thought I could trace the nebulosity from the star *a* as far as one-third of the distance from *a* to *b*, or about $1'7$; but it was broader and more conspicuous nearer to *a*. There again it had the appearance as if on its extreme southern end there was a point of more concentrated light, which made the impression of being another extremely faint star, between which and the star *a* the Nebula extended the whole length. The sketch will give a general idea of what I saw. Also on this evening my observation was controlled by the sharp eye of Dr. Winnecke.

The facility with which I saw the Nebula in March, compared with the difficulty of the first observation, made upon me the impression as if in the interval the brightness of the Nebula had considerably increased; but this impression is probably in a great part due to the extraordinary transparency of the atmosphere we enjoyed in the month of March.

It will be remembered by the readers of the *Monthly Notices*, that my observations made in 1857 on the great Nebula of Orion had left with me the impression as if certain parts of its central region was subject to rapid changes of light. An extensive memoir containing the full account of my observations on this subject is nearly ready for distribution. It will be seen then that all the later observations have confirmed the first impression. The analogy between these observations and the recent discovery of Prof. d'Arrest is conspicuous; but a direct confirmation of my observation by an experienced observer established in a more southern position, and provided with sufficient optical means, is nevertheless very desirable. In this respect I hope Mr. Lassell's new expedition to Malta will afford results of a decisive character.

The extraordinary transparency of the atmosphere during the month of March afforded me the opportunity of making a series of observations of the great Comet of last year (II. 1861), which, I trust, will offer a good normal position for this epoch. These observations bear the date of March 20, 21, 22, 25, and 28; the first observation was made in my absence by Dr. Winnecke; the others by me.

In the present month I have got until now only one determination on April 16, but I hope to get some more observations before the moon returns. The next month the midnight twilight will be too bright in our northern latitude to allow any observation of such a faint object; but in southern climates it might be yet observed some weeks more. With this view I subjoin here an Ephemeris computed by Mr. Liasser from ten to ten days, for the months of May to August, which, in the hands of Mr. Lassell or Mr. Bond, might prove useful:—

at Berlin M.T.	Comet's R.A.	Comet's Decl.	Log r.	Log Δ.
April 30	22 34 ^{h m} .1	76 51 ^o .1	0.648	0.673
May 10	22 55.2	79 7.3	.657	.684
20	23 17.9	81 18.4	.667	.694
30	23 43.8	83 24.0	.676	.704
June 9	0 16.5	85 23.1	.685	.713
19	1 8.9	87 13.6	.694	.722
29	3 32.8	88 43.8	.702	.730
July 9	9 10.3	88 36.8	.710	.737
19	11 9.3	87 15.8	.718	.743
29	11 57.9	85 50.9	.726	.749
Aug. 8	12 29.6	84 21.8	.734	.754
18	12 56.1	83 9.0	0.741	0.758

This Ephemeris shows that about July 1 the Comet will approach the north pole within a degree, a circumstance that, it appears, will complicate a little the reduction of the observations, if such should succeed about that time.

In the month of August the nights will be here again sufficiently dark to admit a look-out for the Comet, though the hope of seeing it distinctly at that advanced period is rather small. At present the distance of the Comet from the Sun and Earth is about 4.5 (the same as the large Comet of 1811 had when it was rediscovered by Wisniewsky, in the summer of 1812); but in August it will be about 5.6. Hence it follows that, taking $\frac{1}{r^2 \Delta^2}$ for the coefficient of its light, this will be about 2.2 times less than it is now. On the other hand there is a strong suspicion, as already Prof. Schönfeld has pointed out, that the intensity of light of this Comet is subject to considerable variability, and this circumstance might, perhaps, favour a rediscovery. This suspicion has now some confirmation by my last observation. In one night it hardly bore any illumination of the field, while in other nights it could be distinctly seen even when the bright wire crossed it. But even in these nights I preferred using the method of celestial triangulation which rendered me such good service at the first appearance of Faye's Comet. On April 16 the diameter of the Comet was estimated about 40". Its light is, even in its present faint state, not quite uniform, but shows distinctly traces of concentration.

Mr. Seeling's last elements of the Comet's orbit in No. 1347 of the *Astronomische Nachrichten*, which have served also for Mr. Liasser's Ephemeris, appears to be already very exact. A preliminary reduction of some observations has given the following differences:—

	In R.A.	C. — O.	In Decl.
March 20	—6·6		+0·1
„ 21	—5·0		0·0
„ 22	—7·6		+0·4

Hence we must conclude that also the period of 419·5 years, assigned to this Comet by Mr. Seeling, is very nearly exact; but, of course, the last observations, and yet more those that might be made in the next months, will very efficaciously contribute to inclose the uncertainty of the period into narrower limits. This expectation will for itself be a sufficient stimulus for astronomers to spend some trouble on a most prolonged observation. But I think the interest attached to this Comet is yet considerably increased by the consideration that the observations made about the time of its greatest proximity to the Earth, if rigorously reduced, might well serve to deduce at least a confirmation, if not a possible correction, of the Sun's parallax. With this view a strict and critical examination of all existing observations and a most uniform and exact determination of all the comparison-stars would be a necessary condition of success. In the last part of the work the Observatory of Pulkowa will be glad to co-operate if there is only some prospect that any astronomers will undertake the laborious task of working out the results systematically.

Three weeks ago I received interesting news from General Chodzko, the Surveyor-general of our Caucasian provinces. This distinguished officer had been engaged last year with a junction of the triangles measured under his direction to the south of the Caucasus with the geodetic operation in the southern part of European Russia. The chain of triangles measured for this purpose crossed the Caucasian mountains almost at right angles, and I suggested to him the idea of using this favourable opportunity for collecting new and exact data concerning the attraction of large mountain masses. Accordingly General Chodzko selected six stations, situated on both sides of the mountain chain, upon which exact determinations of latitude were to be made. These stations were,

1. Tiflis, about 70 miles south of the central line of mountains.
2. Douchet, „ 35 „ „
3. Kobi, very nearly on the central line.
4. Wladikawkas, about 35 miles north of the central line of mountains.
5. Alexandrowskaja, „ 55 „ „
6. Mosdok, „ 70 „ „

On these stations the observations for latitude were executed by Capt. Oblomievsky, the designated Director of the

Observatory of Tiflis, which next year will begin its astronomical activity.

These observations were not yet entirely reduced when General Chodzko wrote me, and it will be particularly regretted that the results for the central station Kobi are not yet at hand. For the other stations General Chodzko gives the following results, which will be exact within a second. Supposing the latitude of Tiflis to be not affected by local attraction, and designing by ϕ the latitude as determined by direct astronomical observations on each station, and by ϕ' the latitude of the same station when deduced geodetically from that of Tiflis, with Bessel's elements of the Earth's figure, we have

For Douchet $\phi' - \phi =$	$+ 25^{\circ} 1'$
Wladikawkas	$- 28^{\circ} 6'$
Alexandrowskaja	$- 12^{\circ} 0'$
Mosdok	$- 5^{\circ} 6'$

Whoever knows a little the geography of the country will agree that it is much more probable that Mosdok is less affected by local attraction than Tiflis. Therefore, attributing the whole amount of $\phi' - \phi$, as found for Mosdok, to the effect of local attraction on the direction of the plumb-line at Tiflis, we shall have

For Tiflis $\phi' - \phi =$	$+ 5^{\circ} 6'$
Douchet	$+ 30^{\circ} 7'$
Wladikawkas	$- 23^{\circ} 0'$
Alexandrowskaja	$- 6^{\circ} 4'$

The latitudes of Douchet and Wladikawkas being respectively $42^{\circ} 5'$ and $43^{\circ} 1'$, we have here as the effect of mountain attraction, on an arc of only $56'$, a difference between the geodetic and astronomical arc of not less than $53'' 7$; and the diminution of the quantity for Tiflis and Alexandrowskaja shows that the effect, as it ought to be, is there less approximately in proportion of the square of the distance from the principal chain of mountains. How far those differences answer the real attraction of the mountain masses will be the object of future inquiries, but even now it might be presumed that the result for the Caucasus will stand in some degree at variance with that obtained by the Indian triangulation for the Himalaya; so that the ingenious hypothetical explanation given by Mr. Airy for the apparent defect of attraction in those mountains will hardly meet with a satisfactory confirmation in the special case of the Caucasus. I have no doubt General Chodzko will continue these interesting researches with all the power he can command, and thereby furnish most precious results both for

position and position. Similar operations will be conducted for 3000 observations in the neighbourhood of Muscova ? Etc., where it was last calculated by the preliminary operations that an error of 15' in position differences of altitude are possible by 15' from the astronomical, and that these differences follow such a law as indicate a systematic defect of ascending matter previous to some distance below the Earth's surface. Mr. Herschel's preliminary operations will be published in a very short time.

Pulkova, April 15th 1862

M. Struve has finally retired from the Presidency of the Observatory of Pulkova; and it will be satisfactory to the Society to learn that M. Otto Struve has been officially appointed as his successor.

Letter from Sir John Herschel to Mr. Hind on the Disappearance of a Nebula in Coma Berenices.

(Communicated by permission of Sir John Herschel.)

I have met with another instance of the disappearance of a well-authenticated Nebula, which I think will interest you.

In M. d'Arrest's *Resultate aus Beobachtungen der Nebelflecken und Sternhaufen — Erste Reihe*, communicated to the Royal Saxon Society of Sciences, and printed in their *Transactions*, occur observations of two Nebulæ which M. d'Arrest considers as new, and sets down as "*novæ*," their places for 1850 being respectively

$$\left. \begin{aligned} 185^{\circ} 33' 21''.5 &= 12^h 22^m 13^s.4 \text{ R.A.} \\ 75^{\circ} 44' 32''.5 &\text{ N.P.D.} \end{aligned} \right\} \text{ (A)}$$

and

$$\left. \begin{aligned} 185^{\circ} 40' 16'' &= 12^h 22^m 41^s.0 \text{ R.A.} \\ 75^{\circ} 32' 2''.0 &\text{ N.P.D.} \end{aligned} \right\} \text{ (B)}$$

(A)'s place is determined by two well-agreeing observations, and it is described as being bright, a 1st-class Nebula, round, 30' in diameter, brighter in the middle to a star 10 mag.

(B)'s place by a single observation — very bright, 1st class, 50' in diameter, round, brighter in the middle; a star 11 mag.

precedes $24^{\text{h}} 6^{\text{m}}$ nearly in the parallel; the place not very exact, but the nebula *frequently seen since in that place*.

No mention is made of any companion-nebula in the same field of view; and M. d'Arrest is so good an observer that any such, of equal or nearly equal brightness, would assuredly, on all these several occasions, not have escaped him.

Both M. d'Arrest's Nebulæ, *and one more*, of an order of brightness little inferior to the latter (B), occur in Sir W. Herschel's catalogues, (A) being identified with H. II. 114, and (B) with one of the two, H. II. 115 and II. 116.

The place of H. II. 114 for 1850 is settled by two observations in sweeps 187 and 199, made on April 8th and 17th, 1784. In the former it is stated to follow $6 \text{ Comæ } 13^{\text{m}} 9^{\text{s}} = 13^{\text{m}} 54^{\text{s}}$ in time, and to be $1^{\circ} 30'$ south of that star; in the latter to precede $34 \text{ Virginis } 16^{\text{m}} 9^{\text{s}} = 16^{\text{m}} 54^{\text{s}}$ in time, and to be $1^{\circ} 28'$ north of it. These give respectively, for its place for 1850,

	h	m	s		°	'	"
{	12	22	16.9		75	45	33
{	12	22	46.5		75	45	16
Mean	12	22	31.7	R.A.	75	45	34
							N.P.D.

Of the identity of this with (A) there can, therefore, be no doubt.

Of H. II. 115 and 116 there occur also two observations in sweeps 187 and 691, made on the 8th of April, 1784, and 14th of January, 1787. In the former they are described thus:—"Two resolvable Nebulæ; they follow the $6^{\text{th}} \text{ Comæ } 14^{\text{m}}$ in time, and are $1^{\circ} 17'$ more south." In the latter they are described separately: the preceding as "very bright, considerably large, follows $6 \text{ Comæ } 13^{\text{m}} 50^{\text{s}}$, south of it $1^{\circ} 19'$;" the following as "pretty bright, pretty large, follows $6 \text{ Comæ } 14^{\text{m}} 5^{\text{s}}$, south of it $1^{\circ} 22'$."

It is certain therefore that both these Nebulæ were seen in the same field of view (for, when so paired together, such was invariably Sir W. Herschel's practice) on two occasions three years apart, so that neither was a comet; and by the second observation their respective situation was

$$\Delta \text{ R.A.} = + 15^{\text{s}}, \quad \Delta \text{ N.P.D.} = + 3';$$

so that, supposing the place assigned in the first observation to refer to the middle point between them, we have their places,—

By observation 1st,

		h	m	s		°	'	"
II. 115	R.A.	12	22	15.4	N.P.D.	75	30	33
II. 116	„	12	22	30.4	„	75	33	33

and by observation 2d,

II. 115	R.A.	^h 12	^m 22	^s 12.9	N.P.D.	[°] 75	['] 34	["] 53
II. 116	„	12	22	27.9	„	75	37	53

and taking the means,

II. 115	R.A.	12	22	14.1	N.P.D.	75	32	43
II. 116	„	12	22	29.1	„	75	35	43

The middle point between which differs from the place of (B) by only 19'.4 in R.A. and 2' 11" in P.D.; so that it is very certain that, had both the objects remained in their places, they must have been in the field of view of a telescope directed on (B).

M. d'Arrest's telescope has amply sufficient power to have shown the missing Nebula (the fainter of the two in all probability, or H. II. 116), which had sufficient illumination to be characterised as "resolvable," and as "pretty bright," or a full second-class Nebula.

Most unfortunately I find no observations of either of these Nebulae in my reviews of the Nebulae. They occur in a very rich region of the heavens; but by taking 6 Comae as a guide, there can be no difficulty in setting a telescope upon the place; and I strongly recommend the point for re-examination.

Collingwood, April 4th, 1862.

Opposition of Mars, 1862. By Lieut. J. M. Gilliss, Director of the U.S. Naval Observatory, Washington.

The co-operation of astronomers is invited in a series of observations upon the planet *Mars*, near the opposition of the present year. Differential measures with the stars designated in the accompanying Ephemeris, will be made at the U. S. Naval Observatory, from 27th August to 7th November, 1862. They will be commenced at one hour before the transit of the planet over the meridian of Washington, and be continued during two hours, the measures being repeated as frequently and as rapidly as is consistent with the utmost care. The comparisons will be confined exclusively to the star selected for the night, and it will be referred to the north and south limbs of the planet at alternate measures, the time at which the planet's limb is observed being noted to the nearest tenth of a second. Both objects will also be observed with the meridian instruments, and their difference of declination will be measured with the micrometer-screw of the circle-telescope.

Astronomers who make these observations are most respectfully requested to forward a copy of them to this establishment as soon thereafter as is practicable, and to transmit, at the same time, a statement respecting the instruments used, together with any information which may influence a discussion of the results.

In preparing the Ephemeris, whenever suitable ones could be obtained, stars were selected from published catalogues, the criterion of availability being a difference of declination not to exceed 4'. For September 17th, it was necessary to take a more distant star. The places of those to which numbers only are given (1 to 11 inclusive) were derived from special observations made with the Washington Equatoreal. To facilitate recognition of the comparison-star selected for each night, all the stars contained in accessible Catalogues and Star-charts which lie near the path of the planet have been inserted on a map accompanying the Ephemeris.

A copy of this last, with the map, will be sent to every Observatory by mail. As some of the copies may not reach their destination, extra numbers will be forwarded to the Secretary, Royal Astronomical Society, London, and to Dr. C. A. F. Peters, at Altona, either of whom will furnish them on application.

*Ephemeris of Stars to be observed with Mars near the
Opposition of the Planet, 1862.*

Date. 1862.	Object.	Mag.	a.			δ.		
			h	m	s	°	'	"
Aug. 27	Mars		1	17	30	+ 3	5	43
	Weisse I. 335	9		20	27		9	43
28	Mars		1	17	45	3	6	48
	Weisse I. 335	9		20	27		9	43
29	Mars		1	17	58	3	7	37
	Weisse I. 335	9		20	27		9	43
30	Mars		1	18	6	3	8	12
	Weisse I. 335	9		20	27		9	43
31	Mars		1	18	12	3	8	22
	Weisse I. 335	9		20	27		9	43
Sept. 1	Mars		1	18	14	3	8	37
	Weisse I. 335	9		20	27		9	43
2	Mars		1	18	13	3	8	28
	Weisse I. 335	9		20	27		9	43

Date.	Object.	Mag.	α .	δ .
1862.			$^{\text{h}}$ $^{\text{m}}$ $^{\text{s}}$	$^{\circ}$ $'$ $''$
Sept. 3	Mars		1 18 9	3 8 5
	Weisse I. 335	9	20 27	9 43
4	Mars		1 18 2	3 7 27
	Weisse I. 335	9	20 27	9 43
5	Mars		1 17 51	3 6 36
	Weisse I. 330	8.9	20 9	5 26
6	Mars		1 17 37	3 5 30
	Weisse I. 330	8.9	20 9	5 26
7	Mars		1 17 19	3 4 12
	Weisse I. 330	8.9	20 9	5 26
8	Mars		1 16 58	3 2 39
	Weisse I. 330	8.9	20 9	5 26
9	* 1	9	1 15 37	3 3 55
	Mars		16 35	0 54
10	* 2	9.10	1 12 38	2 58 47
	Mars		16 7	58 55
11	* 2	9.10	1 12 38	2 58 47
	Mars		15 37	56 45
12	* 2	9.10	1 12 38	2 58 47
	Mars		15 4	54 22
13	* 3	9.10	1 12 28	2 49 50
	Mars		14 27	51 48
14	Mars		1 13 48	2 49 2
	Weisse I. 229	9	15 11	47 49
15	Mars		1 13 5	2 46 6
	Weisse I. 229	9	15 11	47 49
16	Mars		1 12 19	2 42 59
	Weisse I. 229	9	15 11	47 49
17	Mars		1 11 31	2 39 43
	B.A.C. 397	7.8	12 16	33 48
18	Mars		1 10 40	2 36 18
	B.A.C. 397	7.8	12 16	33 48
19	Mars		1 9 46	2 32 45
	B.A.C. 397	7.8	12 16	33 48

Lieut. Gilliss, Opposition of Mars, 1862. 253

Date.	Object.	Mag	a.			δ.		
1862.			h	m	s	°	'	"
Sept. 20	Mars		1	8	50	2	29	4
	B.A.C. 397	7.8		12	16		33	48
21	Mars		1	7	51	2	25	16
	* 4	9		10	17		22	36
22	Mars		1	6	51	2	21	23
	* 4	9		10	17		22	36
23	Weisse I. 20	9	1	3	7	2	15	40
	Mars			5	48		17	25
24	Weisse I. 20	9	1	3	7	2	15	40
	Mars			4	43		13	23
25	Mars		1	3	36	2	9	18
	* 5	9		6	5		11	50
26	* 6	9	1	2	4	2	2	20
	Mars			2	28		5	11
27	Mars		1	1	19	2	1	2
	* 6	9		2	4		2	20
28	Weisse 0°1031	9	0	59	0	1	53	35
	Mars		1	0	8		56	54
29	Mars		0	58	57	1	52	47
	Weisse 0°1031	9		59	0		53	35
30	Mars		0	57	44	1	48	41
	Weisse 0°1023	9		58	36		44	11
Oct. 1	Mars		0	56	31	1	44	39
	Weisse 0°1023	9		58	36		44	11
2	Mars		0	55	17	1	40	39
	Weisse 0°973	9		55	50		36	10
3	Mars		0	54	4	1	36	44
	Weisse 0°973	9		55	50		36	10
4	Mars		0	52	50	1	32	54
	Weisse 0°973	9		55	50		36	10
5	* 7	9	0	48	34	1	32	19
	Mars			51	36		29	10
6	Mars		0	50	23	1	25	34
	Weisse 0°871	8.9		50	36		20	46

Date. 1862.	Object.	Mag.	$\alpha.$			$\delta.$		
			h	m	s	$^{\circ}$	$'$	$''$
Oct. 7	Mars		0	49	10	1	22	5
	Weisse 0°871	8.9		50	36		20	46
8	Mars		0	47	58	1	18	45
	Weisse 0°871	8.9		50	36		20	46
9	Mars		0	46	46	1	15	34
	* 8	9		49	38		17	0
10	Mars		0	45	36	1	12	33
	Weisse 0°806	9		46	34		9	38
11	Mars		0	44	26	1	9	42
	Weisse 0°806	9		46	34		9	38
12	Mars		0	43	18	1	7	3
	Weisse 0°806	9		46	34		9	38
13	Weisse 0°649	8	0	38	0	1	3	20
	Mars			42	11		4	35
14	Weisse 0°649	8	0	38	0	1	3	20
	Mars			41	6		2	10
15	Weisse 0°649	8	0	38	0	1	3	20
	Mars			40	3		0	19
16	Lalande 1123	9	0	35	35	0	56	24
	Mars			39	2		58	31
17	Lalande 1123	9	0	35	35	0	56	24
	Mars			38	2		56	57
18	Lalande 1123	9	0	35	35	0	56	24
	Mars			37	5		55	38
19	Lalande 1123	9	0	35	35	0	56	24
	Mars			36	10		54	35
20	Mars		0	35	17	0	53	47
	Lalande 1123	9		35	35		56	24
21	Mars		0	34	27	0	53	15
	Lalande 1123	9		35	35		56	24
22	Mars		0	33	40	0	52	59
	Lalande 1123	9		35	35		56	24
23	Mars		0	32	55	0	52	59
	Lalande 1123	9		35	35		56	24

Date.	Object.	Mag.	α .	δ .
1862.			h m s	° ' "
Oct. 24	Mars		0 32 13	0 53 17
	Lalande 11123	9	35 35	56 24
25	Mars		0 31 34	0 53 51
	Lalande 11123	9	35 35	56 24
26	Mars		0 30 57	0 54 43
	Lalande 11123	9	35 35	56 24
27	Mars		0 30 24	0 55 51
	Lalande 1097	8.9	34 30	59 34
28	Mars		0 29 53	0 57 17
	Lalande 1097	8.9	34 30	59 34
29	Mars		0 29 26	0 58 59
	Lalande 1097	8.9	34 30	59 34
30	Mars		0 29 2	1 0 59
	* 9	9	29 40	5 34
31	Mars		0 28 40	1 3 15
	* 9	9	29 40	5 34
Nov. 1	Mars		0 28 22	1 5 48
	* 9	9	29 40	5 34
2	Mars		0 28 7	1 8 38
	* 9	9	29 40	5 34
3	* 10	9.10	0 27 44	1 10 0
	Mars		27 54	11 44
4	* 11	9.10	0 26 52	1 16 40
	Mars		27 45	15 6
5	Weisse 0°393	9	0 24 21	1 22 28
	Mars		27 39	18 44
6	Weisse 0°393	9	0 24 21	1 22 28
	Mars		27 36	22 38
7	Weisse 0°420	9	0 25 34	1 23 53
	Mars		27 36	26 47

*U.S. Naval Observatory,
March 1862.*

On the Minor Planet Feronia (79).* By Dr. C. H. F. Peters.

The observations made at the Hamilton College Observatory upon *Maja*, as it was supposed (see Brünnow's *Ast. Not.*, No. 27), from the 29th of May, belong, as Mr. Truman H. Safford has found, to another planet hitherto unknown. Having received, by the kindness of Professor Bond, the places of the comparison-stars from the *Harvard Zones*, not yet printed, I have been enabled to complete the reduction of the eight positions obtained between the 29th of May and 13th of June, and I have computed the following orbit for the new planet:—

Epoch, 1861, Jan. 0^o Washington M.T.

M_0	211	50	4 ^h 27	} Mean Equinox of Epoch.
π	317	39	5 ^h 63	
Ω	207	56	24 ^h 36	
i	5	21	58 ^h 33	
ϕ	7	0	15 ^h 34	
μ	1086	"	924	
Log a	0.3425384			

The semi-axis major appears to be the smallest known of the asteroids, even a little smaller than that of *Flora*; which relation, however, of course is liable to be changed by further observations. The elements were derived from May 30, June 7, and June 13, with regard to the smaller corrections, and represent the whole series as follows:—

	Observed R.A.	C—O.	Observed Decl.	C—O.
May 29	176 39 11 ^s 5	+3 ^s 2	+0 36 12 ^s 8	+2 ^s 2
30	176 47 34 ^s 2	+0 ^s 1	35 8 ^s 3	+0 ^s 3
31	176 56 15 ^s 6	—2 ^s 8	33 50 ^s 4	+1 ^s 4
June 1	177 5 18 ^s 6	—3 ^s 4	32 22 ^s 2	+1 ^s 6
7	178 6 27 ^s 6	+0 ^s 3	20 0 ^s 2	+0 ^s 5
8	178 17 41 ^s 4	—3 ^s 2	17 25 ^s 2	—0 ^s 9
10	178 41 14 ^s 6	+1 ^s 2	11 39 ^s 6	—1 ^s 7
13	179 18 35 ^s 1	0 ^s 0	+0 1 54 ^s 7	—0 ^s 1

The remaining errors are perhaps not larger than may be expected of observations by the ring-micrometer, and upon an object of about 13th magnitude; part of the differences, besides, may be owing to the star-positions. On May 31 and June 1, for example, the same comparison-star was used. The observation on May 29 is not very good; only few comparisons could be obtained.

* See p. 170, where the Planet is called (79). *Feronia* being (71), *Niobe* will be (79).—ED.

In opposition the planet will appear of about the 11th magnitude; and there will be, therefore, no difficulty to find it again on or before the next one, which will happen in September.

At my request Mr. Safford has selected the name; and the number ought to be ⑦, in accordance with the date of the first observation.

In the *Comptes Rendus* (6 Jan., 1862) there is contained an article by M. Leverrier, "On the System of the Planets *Mercury*, *Venus*, the *Earth*, and *Mars*," giving a survey of his researches, as consisting of the three distinct parts, a new examination of the theories, a new discussion of the observations, and lastly, the comparison of the theories and observations. The provisionally assumed masses were

$$\begin{array}{lcl} \text{Mercury} & m & = \frac{1 + v}{3000000} \\ \text{Venus} & m' & = \frac{1 + v'}{401847} \\ \text{The Earth} & m'' & = \frac{1 + v''}{354936} \\ \text{Mars} & m''' & = \frac{1 + v'''}{2680337} \end{array}$$

v, v', v'', v''' being quantities to be determined.

But to make the results of the theory agree with the observations it would be necessary to attribute to these quantities values which are altogether inadmissible. For instance, the discussion of the secular variation of the perihelion of *Mercury* leads to the equation $87'' v'' = +45'', 5$, or the mass of the Earth would require to be increased by nearly one-half its value, and it thus becomes necessary to explain the greater part of the excess of the observed motion of the perihelion of *Mercury* by some extraneous action.

The serious difficulties which present themselves in the motion of the four planets, reduce themselves to the three principal ones; 1°, the excess of the motion of the perihelion of *Mars*; 2°, the excess of the motion of the node of *Venus*; 3°, the excess of the motion of the perihelion of *Mercury*.

The first two difficulties appear to arise from the same cause, the one and the other would be removed by an increase in the mass of the Earth, and this would indicate a perturbing cause placed between the two planets *Venus* and *Mars*. But, M. Leverrier asks, does it follow that the mass of the Earth must really be augmented, or may not the disturbing mass (the action of which should be about equal to a tenth

part of the mass of the Earth) be detached from the Earth, and in this case in what manner is it distributed?

Among the objections, which seem not to permit the necessary addition to be made to the mass of the Earth, is the following; viz., an increase of one-tenth part in the mass of the Earth would disturb the relation that exists between the force of gravity at the surface of the Earth, the mass of the Earth, and the solar parallax, unless the solar parallax were increased by one thirtieth part.

The difficulties disappear by admitting that the perturbing mass is distributed among a considerable number of asteroids, such as exist between *Mars* and *Jupiter*, and whereof only the largest, it is probable, are observed; or such as observation shows to exist at a distance sensible equal to that of the Earth. Such a system of corpuscles would act especially on the perihelion of a planet having a considerable excentricity, and would give it a direct motion; it would less affect, or would not affect at all, the excentricity. It would be therefore, in the motion of the perihelion, attributed exclusively to the terms in the formulæ not depending on the longitude of this element, that a result can be obtained as to the total mass of these corpuscles.

But there is no means of deciding how much of the action is to be attributed to the group at the same distance as the Earth, and how much to the group between *Mars* and *Jupiter*. All that can be done is to assign superior limits to the masses of these groups respectively, by attributing to each of them successively the whole excess in the motion of the perihelion of *Mars*.

Assuming that the perihelia of the disturbing masses are uniformly distributed as to longitude, the results are,—

1°. If the whole excess in the motion of the perihelion of *Mars* is attributed to a ring of asteroids situate at a distance from the Sun equal to that of the Earth, the total mass of these asteroids will be somewhat greater than that of *Mars*, and will be equal to the fraction 0.138 of the mass of the Earth.

2°. If the whole excess is attributed to a group of asteroids between *Mars* and *Jupiter* (distance from the Sun between 2.20 and 3.16) the total mass of the group will be about one third of that of the Earth.

It is now, M. Leverrier thinks, established (*il reste acquis*) that it is not possible to represent all the observations of the system of the four inferior planets, by taking account only of their mutual actions and that of the Sun. But, at least, the difficulties are recognised and circumscribed in such manner that their solution cannot but be obtained, since astronomers now know the direction in which their efforts are to be made. On the one hand, the excess of the motion of the perihelion of *Mercury* is to be accounted for; and if the change of the

obliquity of the equator, deduced from the observations, be accepted, it is necessary to have recourse to the action of an extraneous and hitherto unknown cause. On the other hand, the analogous excess in the motion of the perihelion of *Mars* is to be accounted for; and, if the value of the solar parallax, deduced from the transits of *Venus*, be accepted, recourse must again be had to the action of an extraneous cause.

Disregarding the exceptional facts, and preserving the solar parallax $8''.58$, the masses are definitively found to be,

$$\text{Mercury } m = \frac{1}{4348000}$$

$$\text{Venus } m' = \frac{1}{412150}$$

$$\text{The Earth } m'' = \frac{1}{354030}$$

$$\text{Mars } m''' = \frac{1}{2968300}$$

which are the values adopted in M. Leverrier's tables.

Captain Shea continues to communicate to the Society his Observations of Solar Spots, now extending over a period of 15 years.

Mr. Samuel Sharpe, of Highbury Place, has presented to the Society a 10-inch Reflecting Circle, by Troughton, with its counterpoise stand.

RECENT PUBLICATIONS.

Astronomische Beobachtungen auf der Sternwarte zu Bonn.
Dr. Fr. W. A. Argelander. Dritter Band, Bonner Sternverzeichniss, Erste Section. Bonn, 1859. Vierter Band, Bonner Sternverzeichniss, Zweite Section, Bonn,

contains the approximate mean places of the declinations 2° south and 20° north, for the year 1855; the second section the places of 105075 stars between 20° and 41° in the same epoch, observed and calculated by Dr. E. Schönfeld and Dr. A. Kruger, Director of the Observatory.

The progress of this great work of the Survey of the Firmament, communicated by the direction of the Observatory, recently appeared in the *Monthly Notices*, of the Royal Astronomical Society, p. 57.

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MONTHLY NOTICES
OF THE
ROYAL ASTRONOMICAL SOCIETY.

VOL. XXII.

May 9, 1862.

No. 7.

Dr. LEE, President, in the Chair.

S. H. Miller, Esq., Wisbeach ;
Rev. J. E. Cross, Appleby, near Brigg, Lincolnshire ; and
John Newton, Esq., Well Street,
were balloted for and duly elected Fellows of the Society.

J. S. S. Glennie, Esq., was balloted for and re-elected a
Fellow of the Society.

*Announcement of New Instruments about to be supplied by
Government to the Great Trigonometrical Survey of India.*
By Lieut.-Colonel A. Strange.

It may interest the Society to be informed that the more
purely scientific operations of the Great Trigonometrical Sur-
vey of India are about to receive an impulse by the addition of
several important Instruments, namely,—

- 1 Great Theodolite, with a 3-feet Horizontal Circle.
- 2 Zenith Sectors.
- 3 Transit Instruments.
- 3 Astronomical Clocks.
- 3 Galvanic Registers.

Negotiations for the supply of these Instruments are now in
progress, and the Secretary of State for India in Council has
done me the honour to intrust the superintendence of their
construction to me.

I have been engaged for a considerable period in preparing
the design for the Great Theodolite, the working drawings of
which, in nine large sheets, and a voluminous specification, are
now completed, and embrace the most minute details. Though

based on brief notes by Sir Andrew Scott Waugh, the late Surveyor-General of India, and practically carried out by me, this design comprehends the suggestions of many minds. The endeavour has been to engraft on the excellencies of existing theodolites of the first class, all that the experience of thirty years or more has shown to be desirable, and modern science has rendered possible of achievement, for increasing the power, efficiency, and convenience of the new Instrument. It will present some features of novelty and value sufficient perhaps from time to time to engage the interest of the Society.

The form, size, and arrangements of the other Instruments above enumerated, are still under consideration.

Major J. T. Walker, of H. M. Indian Engineers, the present able Superintendent of the Great Trigonometrical Survey, proposes to employ the Zenith Sectors for adding to the number of points on the Great Meridional Arc of India, the latitudes whereof have been astronomically determined. At present there exist in the northern and more modern portion of this Arc, executed by Sir George Everest, only three such points in an extent of $11^{\circ} 28'$, subdividing the entire Arc into two sections whose amplitudes are respectively $5^{\circ} 24'$ and $6^{\circ} 4'$. Sir Henry James, Superintendent of the Ordnance Survey of Great Britain, suggests that an observed latitude at every degree "would have added very greatly to the weight of the determination of the Earth's figure, and would, besides, have thrown much light upon the question of Himalayan influence." The same object will probably lead Major Walker to use these instruments wherever facilities for doing so profitably are afforded by the extensive and accurate triangulation now spread over a large portion of the Indian peninsula.

The Transit Instruments, Clocks, and Galvanic apparatus, are intended for the determination of longitudes by Electric Telegraph. Major Walker expressly points to the possibility, at no distant date, when certain telegraphic lines now in progress are completed, of ascertaining the absolute difference of Longitude between Greenwich and Kurrachee in Scinde, and thence the true Longitude of every point in India fixed by the Great Triangulation. And he justly observes that "the importance of such a desideratum can scarcely be over-estimated, not only to Science, but also to Navigation, in furnishing the most accurate basis possible for Maritime Charts." This step having been gained, we cannot pause until the Eastern Archipelago, China, and the Australian Colonies, by being linked in the chain, shall cease to present those dangers to seamen which are incident to uncertainty in the longitude.

I may add the hope that the same method will be employed to render available as a geodesic datum the Arc of Parallel*

* This Arc is designated "*The Great Longitudinal Series, Western Section.*" It was commenced in the season 1848-49, and completed 1852-53. The first eighty miles (at the eastern extremity) was executed by Major

lying between Seronj, in Central India, and Kurrachee, in Scinde, comprising about $10\frac{1}{2}$ degrees of longitude, the triangulation of which was executed with the same high class of instrument, and according to the same rigorous system with which Sir George Everest's Great Meridional Arc was measured. It is verified by a Base-line at either extremity, as well as by frequent astronomical determinations of the Azimuth along its course. The character of this work, and its comparative proximity to the Equator (N. latitude about 25°), will constitute it, when completed by the telegraphic observation of the difference of longitude of its extremities and of various points in its length, a valuable accession to the existing meagre array of Arcs of Parallel of the first order.

It is to be regretted that though a chain of triangles connects Seronj in Central India, and Calcutta, and is therefore nominally a continuation of the Arc of Parallel just referred to, this Eastern section cannot properly be combined with the Western for geodesic purposes. In speaking of this work, Sir Andrew Waugh, whilst giving Mr. Olliver, by whom it was executed, full credit "for his indefatigable exertions under difficult circumstances," adds that, "on account of the defective state of instrumental equipments, the professional value of the work is only of a secondary or tertiary order."* The work was carried on during the absence in Europe of Sir George Everest, then Surveyor-General, prior to the introduction of his admirably organised system, and in days when the supply of superior instruments was not so readily conceded as it since has been. In order to place the Eastern on a par with the Western section, the entire triangulation of the former must be executed *de novo* in the modern style and with appropriate apparatus. The line crosses an insalubrious and difficult tract, it is true, but no work of this kind is free from great obstacles. It is to be hoped that, as the terminal Base-lines at Calcutta and Seronj respectively, which constitute so important and costly a branch of such undertakings, are already measured, and as the Western section is complete, the revision of the Eastern section may eventually be justified by the consideration that the two sections combined will confer on mathematical science a contribution so magnificent as that of a continuous Arc of Parallel of the first order, 21 degrees in length.

London, 13th May, 1862.

Renny Tailyour, Bengal Engineers, and the rest by me. This work constitutes, perhaps, the first example of a true Desert being successfully traversed by a great triangulation.

* Return to the House of Commons, Trigonometrical Survey, India, 15th April, 1851, pp. 5, 6.

*Transit of Titan's Shadow across the Disk of Saturn, on
15th April, 1862. By the Rev. W. R. Dawes.*

The sixth satellite of *Saturn* (*Titan*) passed its inferior conjunction with the planet on the night of April 15th, and soon afterwards the shadow of the same satellite transited the disk of *Saturn*.

At 10^h 31^m G.M.T. *Titan* was judged to be at its nearest approach to the planet's north pole. The air was not in a sufficiently good state to render of any use a higher power than 300 on my 8½-inch refractor. With this, the best views showed the satellite quite round, and in loose contact with the disk; but conveying the impression that if the air had been perfectly pure and quiet, a very slight separation might perhaps have been discerned.

Soon after 11^h (time not precisely noted), a shallow circular notch was cut out on the eastern edge of the disk, about one second or a second and a half to the north of the edge of the ring at that place.

At 11^h 8^m, the shadow was judged to have entered one-half its own diameter, the semicircular notch appearing of very considerable size.

At 11^h 14^m, the internal contact was noted; and, in less than half a minute afterwards, the edge of the planet's disk was perceived as a most delicate line of light. The state of the air had improved at this time, and definition with the power then in use (296) was frequently very sharp and steady.

Soon after this, I applied the parallel-wire micrometer, intending to measure the distance between the courses described by the satellite and its shadow, in the direction perpendicular to the axis-major of the ring; but inadvertently the webs were set parallel to the *Earth's* equator instead of *Saturn's*. The mean of six very good measures (with power 286) gave this distance (or *difference of declination*) = 6".84. Taking the inclination of the semi-axis-minor of the ring to the circle of declination at 5° 12', as given in the Table on page 485 of the *Nautical Almanac* for the present year, this difference of declination becomes 7".83, as measured in the direction *perpendicular* to the axis-major of the ring.

The mean of twelve measures of the *difference of right ascension* of the satellite and its shadow, gave 11".24; which, reduced in a similar manner, becomes 10".58 for the distance in the direction *parallel* to the axis-major of the ring.

The shadow passed along the southern edge of the northern equatorial belt, encroaching on the belt by nearly one-third of its own diameter.

At 13^h 46^m, the shadow was judged to be precisely in the middle of the chord it described; and this was tested by the webs of the micrometer, which had been previously separated

to a distance equal to the equatoreal semi-diameter of *Saturn*; and each web being placed alternately on the shadow by the quick slipping-piece attached to the driving cylinder, the webs were found to measure equally well both the eastern and western side of the disk.

After the shadow had passed the middle of its transit, I took eight measures of the distance between the satellite and its shadow in the direction parallel to the axis-major of the ring, the mean of which was $10''.89$. But the state of the air had by this time greatly deteriorated, and the planet was between four and five hours west of the meridian. I therefore prefer the result of the calculation given above, namely, $10''.58$.

On the 2d of November, 1789, a similar phenomenon was observed by Sir W. Herschel. He gives the time when he "discovered a black spot on the following margin of the disk of the planet." But this might probably be some minutes after the centre of the shadow coincided with the edge of the disk. Sir William gives $2^h 8^m 51^s$ as the time which elapsed between his discovery of the spot and its attaining a central position on the disk. The interval between the bisection of the shadow by the limb and its central situation in my observation was $2^h 38^m$. The part of the disk transited was nearly the same on both occasions.

I am not acquainted with any other observations of this interesting phenomenon. In the years 1848 and 1849, when the Sun was nearly in the plane of the ring, I looked out diligently for the transits of *Titan* and its shadow; but either from clouds, or the transit occurring in daylight or when the planet was below the horizon, I was never able to observe it; nor have I heard of any other observer who was more fortunate. During the present apparition of the planet also, I have, until the recent occasion, in vain watched for the occurrence of the phenomenon. It will occur again on May 1st and 17th; but I believe that on both those occasions the shadow will be hidden from our view by the interposition of the ring. On the 1st, the path of the shadow will lie within $1''$ to the north of *Saturn's* equator; and on the 17th it will fall on the ring itself, which, from its extremely feeble illumination, will appear as a very dark line across the planet; and it seems exceedingly doubtful whether the shadow, notwithstanding its intense blackness, will be at all discernible upon it.

The *size* of the shadow, however, is far greater than I was prepared to expect. I carefully estimated it at little less than $1''$ in diameter—certainly not less than $0''.8$. It may reasonably be concluded from this that some part of the surface of the satellite is not very reflective; and that, with a large amount of optical power, it might perhaps be perceived as a *dark spot* on the disk of the planet (as is *always* the case with the third and fourth satellites of *Jupiter*), especially if

it should happen in its transit to be projected on the bright equatoreal region. This, however, will not occur during the present season; for though, on August 5th, *Titan* will transit the northern portion of that region, yet it will occur while daylight is so strong as to render it utterly improbable that the satellite could be seen on the disk at all, and very unlikely that even its shadow should be detected.

The third transit of the shadow from the present time will occur on the evening of June 2d; and as it will then fall on the *south* side of the ring, it may probably be seen passing along the southern edge of the extremely narrow *shadow of the ring*; and as its ingress will not take place till about fifty minutes after sunset, and the planet will be only about $2\frac{1}{2}$ hours west of the meridian, it is hoped that the phenomenon will be extensively observed, if the sky should be clear.

The following will be approximately the times of the ingress of *Titan's* shadow for the next seven transits; but the strong daylight and the planet's distance from the meridian will combine to render the last two or three of them very difficult to observe, if not absolutely invisible.

Approximate G.M.T. of Ingress of the Shadow of *Titan*.

	^h	^m
1862, May 1, at	10	24
17,	9	41
June 2,	8	57
18,	8	14
July 4,	7	30
20,	6	47
Aug. 5,	6	3

From the great size of the shadow, I believe that the ordinary aperture of a 5-foot refractor ($3\frac{1}{4}$ to 4 inches) would suffice to show it under favourable circumstances of atmospheric purity and altitude of the planet, provided the defining power of the instrument is extremely good.

Hopefield Observatory, Haddenham, near Thame,
1862, April 28.

Transit of Titan's Shadow over the Disk of Saturn, on
1st May, 1862. By the Rev. W. R. Dawes.

Clouds most unfortunately prevented the observation of the transit of the shadow of *Titan* over the disk of *Saturn* on the night of May 1st. A glimpse showed the satellite near its inferior conjunction at $8^h 15^m$; but after that the planet re-

mained invisible; and, consequently, I have no means of applying, as I hoped to do, any correction from observation to the calculated time given at the conclusion of my former paper.

Hopefield Observatory, 1862, May 3.

In a letter to the Editor, dated 26th May, Mr. Dawes writes that on the 17th he made a capital observation of the transit of *Titan's* shadow; and that on the 25th he watched an immersion of that satellit: into the *shadow* of *Saturn*.

Transit of Mercury of 11th November, 1861.

(Extract of a Letter from Charles Todd, Esq., Observatory and Telegraph Department, Adelaide, to the Astronomer Royal, dated 1861, Nov. 26.)

I had a glorious day for observing the transit of *Mercury* on the 12th instant (11th G. T.), with a Dollond of $2\frac{1}{4}$ " aperture.

	^h ^m ^s	
Total Ingress	2 34 12 A.M.T., very exact.	
Egress, int. cont.	6 30 29 A.M.T., rather doubtful; Sun low.	
Total Egress	6 32 19 A.M.T., very doubtful; limb boiling; Sun near setting.	

Some very fine large clusters of spots on the Sun.

Observations of Comet II. 1861, made with the Northumberland Equatoreal at the Cambridge Observatory. By J. C. Adams, Esq., Director of the Observatory.

	G.M.S.T. 1861.			Observed R.A.	Parallax × Δ	Observed N.P.D.	Parallax × Δ
	^d	^h	^m ^s	^h ^m ^s			
June 30	11	6	7.4	6 40 14.94	+0.127	43 25 37.1	-8.343
		11	19 51.1	6 40 40.50	+0.099	43 19 35.0	-8.391
July 2	10	41	46.6	8 30 28.47	+0.541	...	...
		10	57 47.4	..	..	27 36 40.5	-6.571
3	9	57	55.6	9 39 53.92	+0.822	24 10 11.5	-4.128
		11	4 52.4	9 43 15.42	+0.726	24 4 38.6	-5.330
5	10	29	33.1	11 44 52.88	+0.868	23 38 32.8	-2.301
8	9	54	51.8	13 17 34.82	+0.624	27 54 50.1	-0.573
		10	53 7.9	13 18 22.15	+0.706	27 58 30.1	-1.627
9	11	4	31.9	13 35 4.31	+0.673	29 23 45.7	-1.767
		11	56 10.5	13 35 36.11	+0.709	29 26 47.9	-2.768
10	11	7	1.7	13 42 55.33	+0.641	30 40 45.8	-1.800
13	11	22	27.6	14 13 11.05	+0.528	33 47 49.3	-2.208

		G.M.S.T. 1861.			Observed R.A.			Parallax x A.	Observed N.P.D.			Parallax x A.
	^d	^h	^m	^s	^h	^m	^s		[°]	[']	^{''}	
July	23	10	32	49.0	14	46	40.09	+0.469	39	26	26.8	-2.151
	26	10	32	17.3	14	51	52.27	+0.466	40	27	2.2	-2.369
	27	10	33	40.2	14	53	23.97	+0.469	40	44	52.1	-2.456
	31	10	26	32.3	14	58	53.10	+0.462	41	47	58.5	-2.630
Aug.	1	10	35	45.8	15	0	8.70	+0.473	42	2	10.6	-2.835
	2	10	32	1.3	15	1	21.77	+0.469	42	15	28.0	-2.850
	6	10	6	13.3	15	5	58.48	+0.448	43	3	51.5	-2.718
	8	11	36	5.3	15	8	15.87	+0.508	43	26	28.1	-4.273
	13	10	50	16.2	15	13	38.37	+0.489	44	14	56.1	-3.837
	14	10	5	46.4	15	14	40.53	+0.459	44	23	31.9	-3.202
	15	10	17	49.8	15	15	45.60	+0.470	44	32	18.2	-3.444
	16	10	9	30.0	15	16	49.44	+0.404	44	40	41.4	-3.375
	19	10	29	28.4	15	20	3.57	+0.480	45	4	48.1	-3.860
	20	10	17	53.8	15	21	7.81	+0.474	45	12	18.1	-3.735
	21	9	22	2.6	15	22	10.59	+0.429	45	19	26.2	-2.960
	23	9	45	40.3	15	24	22.39	+0.454	45	33	50.1	-3.414
	24	9	31	49.0	15	25	27.54	+0.443	45	40	36.9	-3.265
	27	10	12	6.3	15	28	50.08	+0.475	46	0	31.3	-4.034
	28	10	12	2.4	15	29	57.85	+0.476	46	6	45.7	-4.088
	30	9	22	4.7	15	32	10.76	+0.445	46	18	33.4	-3.437
Sept.	3	9	57	56.4	15	36	50.93	+0.472	46	40	58.0	-4.183
	6	8	47	24.9	15	40	21.31	+0.427	46	55	58.1	-3.285
	7	9	17	36.4	15	41	35.06	+0.453	47	0	49.0	-3.770
	9	8	45	16.6	15	43	59.40	+0.431	47	10	1.5	-3.394
	10	9	44	31.5	15	45	16.09	+0.470	47	14	35.8	-4.323
	11	9	19	54.9	15	46	29.07	+0.460	47	18	47.9	-3.996
	12	10	24	59.8	15	47	46.77	+0.477	47	23	9.1	-5.047
	13	10	37	13.6	15	49	3.41	+0.475	47	27	11.9	-5.284
	14	9	45	6.2	15	50	16.27	+0.472	47	30	53.2	-4.521
	23	10	12	4.0	16	2	1.87	+0.470	47	59	51.8	-5.342
Oct.	9	9	30	36.3	16	24	25.11	+0.467	48	25	8.7	-5.358
	11	8	57	45.5	16	27	20.63	+0.468	48	25	45.7	-4.935
	12	10	38	55.7	16	28	56.26	+0.429	48	25	51.1	-3.473
	14	9	55	27.1	16	31	52.46	+0.452	48	26	0.1	-5.918
	15	9	14	45.4	16	33	20.43	+0.466	48	25	40.7	-5.342
	16	8	32	50.6	16	34	47.90	+0.467	48	25	22.8	-4.740
	23	8	21	25.1	16	45	33.56	+0.469	48	18	53.2	-4.813
	28	7	35	56.1	16	53	23.50	+0.460	48	10	7.4	-4.290
Nov.	1	7	36	39.0	16	59	49.13	+0.465	48	0	34.7	-4.426
	2	8	57	36.6	17	1	31.62	+0.464	47	57	36.8	-5.698
		9	1	53.1	17	1	32.41	+0.462	47	57	37.9	-5.761
	5	8	3	14.1	17	6	21.53	+0.473	47	48	43.1	-4.959
	6	7	52	51.5	17	7	59.25	+0.473	47	45	28.2	-4.830

	d	G.M.S.T. 1861.			Observed R.A.			Parallax × Δ.	Observed N.P.D.			Parallax × Δ.
		h	m	s	h	m	s		°	'	″	
Nov.	7	8	2	21.5	17	9	38.79	+0.474	47	41	56.1	-5.008
	9	8	43	42.4	17	13	1.20	+0.466	47	34	15.6	-5.721
	11	8	38	55.1	17	16	20.95	+0.465	47	26	31.6	-5.689
	20	6	53	55.6	17	31	30.01	+0.476	46	43	49.4	-4.315
	23	7	49	1.8	17	36	44.66	+0.482	46	26	28.5	-5.327
	27	6	55	5.0	17	43	39.16	+0.485	46	2	18.8	-4.507
	28	6	56	14.3	17	45	24.37	+0.486	45	55	48.9	-4.554
	30	7	58	3.9	17	48	59.05	+0.479	45	42	56.9	-5.575
Dec.	3	7	27	26.7	17	54	16.40	+0.490	45	21	10.9	-5.193
	4	7	55	49.1	17	56	5.36	+0.480	45	13	45.6	-5.653
	5	8	7	48.6	17	57	53.10	+0.472	45	6	8.5	-5.882

The foregoing values were deduced as follows:—

	d	R.A. Comet—Star.		No. of Comp.	N.P.D. Comet—Star.		No. of Comp.	Star.
		h	m		°	'		
June	30	— 6	1.85	1	— 7	37.2	1	<i>a</i>
		— 11	50.63	1	— 31	27.0	1	<i>b</i>
July	2	{ — 11	26.54	3	..	..	..	{ <i>c</i> <i>d</i>
		{ — 8	10.07		{ + 5	23.9	2	{ <i>c</i> <i>d</i>
					{ — 2	54.2		
	3	— 28	2.06	1	— 1	49.4	1	<i>e</i>
		+ 3	46.57	3	+ 18	55.2	3	<i>f</i>
	5	— 4	25.66	6	— 20	23.8	6	<i>g</i>
	8	— 27	41.47	1	+ 5	53.8	1	<i>h</i>
		+ 3	2.19	5	+ 6	13.7	5	<i>i</i>
	9	— 29	25.99	1	— 36	22.5	1	<i>k</i>
		— 3	33.03	2	+ 17	31.6	2	<i>l</i>
	10	+ 2	11.99	6	— 5	28.7	6	<i>m</i>
	13	— 6	13.30	4	+ 0	24.9	4	<i>n</i>
	23	— 5	8.51	4	— 21	37.8	4	<i>o</i>
	26	— 5	2.31	7	+ 11	44.6	7	<i>p</i>
	27	+ 5	42.19	4	— 0	32.1	4	<i>q</i>
	31	— 0	21.65	11	— 0	9.5	11	<i>r</i>
Aug.	1	+ 0	53.98	6	+ 14	2.6	6	<i>r</i>
	2	+ 5	25.25	6	+ 5	11.4	6	<i>s</i>
	6	+ 1	54.96	8	+ 4	32.4	8	<i>t</i>
	8	— 5	18.81	3	— 25	49.5	3	<i>u</i>
	13	— 5	47.78	6	+ 0	51.3	6	<i>v</i>
	14	— 4	45.59	2	+ 9	27.1	2	<i>v</i>
	15	+ 1	48.85	8	+ 3	47.8	8	<i>w</i>
	16	+ 2	52.72	6	+ 12	10.9	6	<i>w</i>
	19	— 1	12.06	8	— 7	43.3	8	<i>x</i>

	R.A. Comet—Star.	No. of Comp.	N.P.D. Comet—Star.	No. of Comp.	Star.
Aug. 20 ^d	+ 0 59 ^m 93 ^s	8	+ 3 45 ^m 3 ^s	8	y
21	+ 0 55 ^m 02 ^s	8	+ 6 54 ^m 3 ^s	8	x
23	+ 2 42 ^m 01 ^s	8	+ 3 30 ^m 7 ^s	8	x
24	+ 3 47 ^m 18 ^s	8	+ 10 17 ^m 3 ^s	8	x
27	— 4 51 ^m 96 ^s	6	+ 4 7 ^m 9 ^s	6	aa
28	— 3 44 ^m 16 ^s	6	+ 10 22 ^m 2 ^s	6	aa
30	+ 1 44 ^m 31 ^s	8	— 3 36 ^m 4 ^s	8	bb
Sept. 3	+ 2 3 ^m 92 ^s	6	— 10 3 ^m 6 ^s	6	cc
6	— 1 9 ^m 31 ^s	6	— 9 53 ^m 5 ^s	6	dd
7	— 4 41 ^m 08 ^s	6	— 0 3 ^m 6 ^s	6	ee
9	— 2 16 ^m 69 ^s	6	+ 9 8 ^m 7 ^s	6	ee
10	— 2 37 ^m 66 ^s	6	+ 5 12 ^m 8 ^s	6	ff
11	— 1 24 ^m 66 ^s	6	+ 9 24 ^m 8 ^s	6	ff
12	— 0 6 ^m 93 ^s	8	+ 13 45 ^m 9 ^s	8	ff
13	+ 1 9 ^m 73 ^s	6	+ 17 48 ^m 5 ^s	6	ff
14	+ 2 22 ^m 62 ^s	6	+ 21 29 ^m 7 ^s	6	ff
23	— 2 36 ^m 92 ^s	4	— 32 34 ^m 3 ^s	4	gg
Oct. 9	+ 1 46 ^m 87 ^s	8	— 1 15 ^m 5 ^s	8	hh
11	— 4 43 ^m 97 ^s	6	+ 6 7 ^m 8 ^s	6	ii
12	— 3 8 ^m 32 ^s	2	+ 6 13 ^m 0 ^s	2	ii
14	— 5 44 ^m 14 ^s	4	— 6 20 ^m 8 ^s	5	kk
15	— 4 16 ^m 15 ^s	6	— 6 40 ^m 4 ^s	6	kk
16	— 2 48 ^m 66 ^s	8	— 6 58 ^m 4 ^s	8	kk
23	+ 1 0 ^m 70 ^s	6	+ 13 15 ^m 6 ^s	6	ll
28	— 2 20 ^m 76 ^s	8	— 10 55 ^m 2 ^s	8	mm
Nov. 1	+ 0 57 ^m 26 ^s	8	+ 6 18 ^m 9 ^s	8	nn
2	— 0 34 ^m 14 ^s	7	— 0 6 ^m 2 ^s	7	oo
	+ 2 40 ^m 55 ^s	2	+ 3 21 ^m 9 ^s	2	nn
5	— 2 47 ^m 38 ^s	8	+ 4 58 ^m 1 ^s	8	pp
6	— 1 9 ^m 64 ^s	7	+ 1 42 ^m 9 ^s	7	pp
7	+ 0 29 ^m 91 ^s	9	— 1 49 ^m 5 ^s	9	pp
9	+ 2 39 ^m 71 ^s	4	— 3 46 ^m 3 ^s	3	qq
11	— 0 48 ^m 10 ^s	9	— 9 12 ^m 8 ^s	9	rr
20	+ 1 1 ^m 34 ^s	8	+ 13 17 ^m 5 ^s	8	ss
23	+ 0 19 ^m 00 ^s	6	— 0 59 ^m 9 ^s	5	tt
27	— 0 15 ^m 83 ^s	8	+ 11 34 ^m 8 ^s	6	uu
28	+ 1 29 ^m 36 ^s	8	+ 5 4 ^m 7 ^s	6	uu
30	— 0 51 ^m 62 ^s	8	— 5 34 ^m 2 ^s	6	vv
Dec. 3	— 1 9 ^m 17 ^s	8	+ 4 43 ^m 9 ^s	6	ww
4	+ 0 32 ^m 79 ^s	8	— 2 41 ^m 7 ^s	6	ww
5	+ 2 27 ^m 53 ^s	8	— 10 19 ^m 1 ^s	6	ww

The determinations of N.P.D. from July 2 to July 9, inclusive, are liable to some uncertainty, in consequence of the defective state of the clamp by

which the declination-rod was attached to the polar frame. The determinations of R.A. however are trustworthy.

The R.A. and N.P.D. for July 2 are obtained by taking a mean between the results of the comparisons with (c) and (d).

It is probable that in the observation of Nov. 30 the recorded micrometer-reading was too great by 5 revolutions, and that the N.P.D. should consequently be diminished by $5'' = 43''.2$.

*Assumed Mean Places of the Stars of Comparison
for 1861.0.*

Star.	R.A. 1861.0. h m s	N.P.D. 1861.0. ° ' "	Authority.
<i>a</i>	6 46 15.02	43 33 14.32	Johnson 1841
<i>b</i>	6 52 29.36	43 51 2.00	Arg. 7473
<i>c</i>	8 41 53.41	27 31 18.42	Johnson 2212
<i>d</i>	8 38 36.47	27 39 33.30	Arg. 9299
<i>e</i>	10 7 54.05	24 12 1.81	Johnson 2464
<i>f</i>	9 39 26.98	23 45 44.11	" 2396
<i>g</i>	11 49 16.42	23 58 58.28	Arg. 12183-84
<i>h</i>	13 45 13.86	27 48 58.73	Johnson 3103
<i>i</i>	13 15 17.63	27 52 18.45	Arg. 13563
<i>k</i>	14 4 27.81	30 0 10.61	Johnson 3147
<i>l</i>	13 39 6.75	29 9 18.43	" 3084
<i>m</i>	13 45 40.92	30 46 16.61	" 3104
<i>n</i>	14 19 21.88	33 47 26.83	Arg. 14545
<i>o</i>	14 51 46.18	39 48 7.45	Johnson 3293
<i>p</i>	14 56 52.21	40 15 20.75	Arg. 15039
<i>q</i>	14 47 39.45	40 45 27.01	" 14924-5 and 6
<i>r</i>	14 59 12.46	41 48 11.30	Johnson 3318
<i>s</i>	14 55 54.28	42 10 19.81	" 3306
<i>t</i>	15 4 1.33	42 59 22.55	Arg. 15138, 39 & 4
<i>u</i>	15 13 32.48	43 52 21.45	" 15266
<i>v</i>	15 19 24.05	44 14 8.99	" 15347
<i>w</i>	15 13 54.71	44 28 34.20	" 15272
<i>x</i>	15 21 13.64	45 12 35.38	Johnson 3385
<i>y</i>	15 20 5.93	45 8 36.32	Arg. 15355
<i>z</i>	15 21 38.49	45 30 23.41	Johnson 3387
<i>aa</i>	15 33 40.19	45 56 27.99	" 3423
<i>bb</i>	15 30 24.17	46 22 13.89	" 3413
<i>cc</i>	15 34 45.30	46 51 5.65	" 3431
<i>dd</i>	15 41 28.95	47 5 56.02	" 3448
<i>ee</i>	15 46 14.48	47 0 57.43	" 3462
<i>ff</i>	15 47 52.16	47 9 27.67	" 3464
<i>gg</i>	16 4 37.39	48 32 30.79	H. C. 29530
<i>hh</i>	16 22 37.14	48 26 28.41	" 30042
<i>ii</i>	16 32 3.53	48 19 43.04	Eq. Comparison.
<i>kk</i>	16 37 35.56	48 32 26.10	H. C. 30489
<i>ll</i>	16 44 32.00	48 5 41.91	" 30687

Star.	R.A. 1861 ^o .	N.P.D. 1861 ^o .	Authority.
m m	16 55 43 ^{h m s} .43	48 21 7 ^{o ' "} .36	H. C. 31031
n n	16 58 51 ^{h m s} .13	47 54 20 ^{o ' "} .14	B. Z. 426. 16 ^h 57 ^m 41 ^s
o o	17 2 5 ^{h m s} .02	47 57 47 ^{o ' "} .50	Eq. Comparison.
p p	17 9 8 ^{h m s} .21	47 43 49 ^{o ' "} .86	H. C. 31417
q q	17 10 20 ^{h m s} .85	47 38 5 ^{o ' "} .93	" 31456
r r	17 17 8 ^{h m s} .42	47 35 49 ^{o ' "} .01	" 31697
s s	17 30 28 ^{h m s} .18	46 30 36 ^{o ' "} .13	" 32154 and 5
t t	17 36 25 ^{h m s} .19	46 27 32 ^{o ' "} .75	Johnson 3741
u u	17 43 54 ^{h m s} .58	45 50 48 ^{o ' "} .38	" 3763
v v	17 49 50 ^{h m s} .27	45 48 35 ^{o ' "} .65	B. Z. 478. 17 ^h 47 ^m 53 ^s
w w	17 55 25 ^{h m s} .32	45 16 31 ^{o ' "} .59	Eq. Comparison.

The place assumed for the star (*i i*) is derived from equatorial comparisons made on Oct. 15 with H. C. 30489. The place of (*o o*) is derived from equatorial comparisons made on Nov. 20 with B. Z. 426. 16^h 57^m 41^s, and the place of (*w w*) from equatorial comparisons with Johnson 3795 made on Feb. 20, 1862.

The observations up to July 13 were made by Professor Challis, and the subsequent ones by Mr. Bowden, the senior Assistant at this Observatory.

Cambridge Observatory,
April 25th, 1862.

Observations of Encke's Comet. By W. Scott, Astronomer for New South Wales.

(Extract of a Letter to the Astronomer Royal, dated Observatory, Sydney, March 22, 1862.)

"I send you herewith the only good observations I have been enabled to obtain of Encke's Comet. The weather has been cloudy or hazy for the last two months, and the Comet was, at the best, very indistinct and ill defined.

Observations of Encke's Comet with the 7-inch Equatoreal and Ring-Micrometer.

Greenwich M.T.	R.A.		Decl.		Star.
	Comet	Star.	Comet	Star.	
Feb. 23	5 45 14 ^{d h m s}	-5 37 ^{m s} .7	+4 25 ^{' "}		<i>a</i>
	53 24	-1 37 ^{m s} .8	-0 3		<i>b</i>
	6 1 36	-1 36 ^{m s} .3	-0 13		<i>b</i>
	7 6	-1 35 ^{m s} .7	+0 7		<i>b</i>
	11 31	-1 36 ^{m s} .0	+0 3		<i>b</i>
	11 31	-5 35 ^{m s} .1	+4 5		<i>a</i>

Stars of Comparison; *a*, B.A.C. 7216; *b*, 8th mag.
R.A. 20^h 38^m 22^s; Decl. -25° 25'.

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Greenwich M.T.				R.A.	Decl.	Star.
d	h	m	s	Comet—Star.	Comet—Star.	
Feb. 24	5	43	26	—3 27 ⁶	+5 24	<i>a</i>
	49	14		—3 27 ²	+5 17	<i>a</i>
	56	6		—3 26 ⁸	+5 29	<i>a</i>
	6	3	6	+0 33 ⁸	+0 58	<i>b</i>
	9	40		+0 34 ³	+1 2	<i>b</i>
	12	2		+0 34 ²	+0 53	<i>b</i>

Stars of Comparison same as before.

Results of Meridional Observations of Small Planets; Occultation of a Star by the Moon; and Phenomena of Jupiter's Satellites; observed at the Royal Observatory, Greenwich, during the month of April, 1862.

(Communicated by the Astronomer Royal.)

Flora (8).

Mean Solar Time of Observation.				R.A. from Observation.	N.P.D. from Observation.
	h	m	s	h m s	° ' "
1862, April 3	13	14	50 ⁶	14 3 15 ²⁷	92 22 40 ⁹⁹
	15	12	16 16 ⁵	13 51 50 ²²	91 11 5 ⁴⁰
	17	12	6 25 ²	13 49 50 ⁴⁰	91 0 4 ⁰⁴
	21	11	46 42 ²	13 45 50 ³⁹	90 39 16 ⁹⁰
	22	11	41 46 ⁹	13 44 50 ⁸⁷	90 34 27 ⁷⁶
	24	11	31 57 ⁴	13 42 52 ⁸⁰	90 25 6 ⁰⁹
	26	11	22 9 ⁵	13 40 56 ³⁸	90 16 17 ⁶²
	28	11	12 23 ⁸	13 39 2 ²⁶	90 8 8 ⁴⁸
	30	11	2 41 ¹	13 37 11 ⁰⁴	90 0 35 ⁰²

Melpomene (18).

Mean Solar Time of Observation.				R.A. from Observation.	N.P.D. from Observation.
	h	m	s	h m s	° ' "
1862, April 22	13	11	57 ⁵	15 15 16 ²⁸	92 28 42 ⁶⁴
	29	12	38 18 ²	15 9 7 ³⁰	91 43 32 ⁵⁰

Fortuna (19).

Mean Solar Time of Observation.				R.A. from Observation.	N.P.D. from Observation.
	h	m	s	h m s	° ' "
1862, April 17	9	55	53 ⁵	11 38 57 ³³	88 47 7 ⁶¹
	21	9	38 10 ⁴	11 36 57 ⁴⁷	88 31 21 ⁷⁶

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Thalia (29).

Mean Solar Time of Observation.	E.A. from Observation.	N.P.D. from Observation.
h m s	h m s	° ' "
1862, April 3	9 32 13.4	10 20 1.57
		62 11 46.71

Euterpe (27).

Mean Solar Time of Observation.	E.A. from Observation.	N.P.D. from Observation.
h m s	h m s	° ' "
1862, April 3	12 49 26.1	13 37 46.66
		97 26 2.94
17	11 40 56.1	13 24 17.12
		96 9 42.67
21	11 21 29.1	13 20 33.19
		95 49 26.26
24	11 7 0.5	13 17 51.80
		95 35 0.59
25	11 2 12.6	13 16 59.70
		95 30 24.92
28	10 47 55.0	13 14 29.45
		95 17 23.52
29	10 43 11.2	13 13 41.41
		95 13 15.87

Amphitrite (20).

Mean Solar Time of Observation.	E.A. from Observation.	N.P.D. from Observation.
h m s	h m s	° ' "
1862, April 17	9 45 9.8	11 28 11.83
		87 59 18.66
21	9 27 35.5	11 26 20.37
		87 54 55.24
23	9 18 57.3	11 25 34.38
		87 53 30.20
28	8 57 48.1	11 24 4.40
		87 52 13.47
29	8 53 38.8	11 23 51.06
		87 52 26.30

All the observations of N.P.D. have been corrected for refraction and parallax.

The reappearance of B.A.C. 4923, on 1862, April 15, at the Moon's bright limb was observed by Mr. Criswick to take place at 13^h 50^m 34^s.7 G.M.T.

Phenomena of Jupiter's Satellites.

Day of Observation.	Satellite.	Phenomenon.	Mean Solar Time.	Observer.
1862.			h m s	
April 15	I	Egress, bisection	13 58 48.6	C.
15	I	„ last cont.	14 0 18.3	C.
17	I	„ bisection	8 25 25.1	J. C.
22	I	Ingress, bisection	13 29 58.8	E.
24	I	Egress, bisection	10 12 7.9	D.
24	I	„ last cont.	10 15 7.4	D.
25	I	Eclipse, reapp.	8 17 55.3	J. C.
25	II	Eclipse, reapp.	11 11 55.0	J. C.

The initials D., E., C., and J. C., are respectively those of Mr. Dunkin, Mr. Ellis, Mr. Criswick, and Mr. Carpenter.

Ephemeris of Proserpine ☾. By M. Hoek, Director of the Observatory of Utrecht.

(Letter to the Astronomer Royal, dated Utrecht, 1862, May 20.)

“J’ai l’honneur de vous adresser une éphéméride pour l’opposition prochaine de *Proserpine* ☾, éphéméride qui a été déduite par interpolation, du *Jahres-éphéméride* dans le *Berliner Astronomisches Jahrbuch für 1864*, et qui a déjà été corrigée (d’après l’indication de M. Kam à Leyde) par — 3^e en R.A., et 0^o en Decl.

“Monsieur Kam a eu la complaisance de chercher la planète, de sorte que vous la trouverez aux endroits suivantes:—

T.M. de Berlin. 1862.	R.A. h m s	Decl. ° ' "	Log Δ.	Temps de Transmission de la Lumière. m s
Mai 25 ⁵	17 29 32	— 26° 15' 3	0.1628	11 57.5
26 ⁵	28 42	16.6	.1618	55.7
27 ⁵	27 50	17.8	.1608	54.0
28 ⁵	26 58	19.0	.1598	52.4
29 ⁵	26 4	20.2	.1589	51.0
30 ⁵	25 9	21.4	.1581	49.7
31 ⁵	24 13	22.5	.1573	48.5
Juin 1 ⁵	23 17	23.5	.1567	47.4
2 ⁵	22 20	24.5	.1561	46.5
3 ⁵	21 23	25.3	.1556	45.7
4 ⁵	20 25	26.1	.1552	45.0
5 ⁵	19 27	26.9	.1548	44.5
6 ⁵	18 28	27.5	.1546	44.1
7 ⁵	17 29	28.1	.1544	43.8
8 ⁵	16 29	28.7	.1543	43.6
9 ⁵	15 29	29.2	.1543	43.5
10 ⁵	14 29	29.6	.1543	43.5
11 ⁵	13 29	30.0	.1545	43.7
12 ⁵	12 29	30.3	.1547	44.0
13 ⁵	11 30	30.5	.1549	44.5
14 ⁵	10 31	30.6	.1553	45.2
15 ⁵	9 33	30.7	.1557	46.0
16 ⁵	8 35	30.7	.1563	46.9
17 ⁵	7 37	30.7	.1569	47.9
18 ⁵	6 40	30.7	.1575	49.0
19 ⁵	5 44	30.6	.1583	50.1
20 ⁵	4 48	30.4	.1591	51.4
21 ⁵	3 53	30.2	.1600	52.8
22 ⁵	2 59	29.9	.1610	54.4
23 ⁵	2 5	29.5	.1620	56.2
24 ⁵	17 1 12	— 26 29.1	0.1632	11 58.2

“ Si vous vouliez communiquer cette éphéméride aux astronomes Anglais qui pourraient s’y intéresser, vous m’obligeriez fort.”

Further Note on the supposed Observation of an Intra-Mercurial Planet on the 12th of February, 1820.

Mr. Carrington has been favoured with the following letter from Dr. von Littrow, which he hastens to communicate a translation of, referring at the same time to the *Monthly Notices*, vol. xx. p. 194.

“ Vienna, April 13th, 1862.

“ A fortunate chance has, at length, led me to-day to a source whence I have obtained further information respecting the observation of Steinheibel.

“ In the *Vienna Times* of April 27th, 1820, there is to be found the following notice, communicated probably by my father:—

“ ‘ Mr. Steinheibel, who for the last four years has daily observed the Sun and recorded his spots and faculæ with care in a diary, on February 12th (1820), at 10^h 45^m in the morning, observed a spot, which was distinguished from all the rest by its well-defined circular form, by its equally circular atmosphere, by its orange-red colour, and especially by its unusual motion, completing the diameter of the Sun in nearly five hours. As he made this interesting observation during a country excursion, it was impossible to have recourse to instruments or to communicate the phenomenon early enough to others; yet he is ready to answer fully every question put to him about this occurrence. It is very possible that a planet might be discovered in this way, having its orbit within that of *Mercury*; and should the zeal with which Mr. Steinheibel has pursued this class of observations for a series of years, be rewarded by such a happy result, and lead him to publish his observations on the Sun, they would not be without interest for the public.’

“ I have in a former letter incorrectly written the name ‘Steinheibel,’ according to Olbers, ‘Steinhübel.’ He lived for some time as Abbé at Vienna, and subsequently at Kremsmünster; at both of which places he occupied himself continuously with observations of the Sun. The above observation of his is given so differently to that of Starke, that I should consider it independent of the latter.”

Mr. Lassell writes to correct an error (p. 164 of the *Monthly Notices*), where it is stated that the new star discovered by him within the trapezium of the great nebula of

Orion "appears to be about a full magnitude less than that known as 'the sixth star;' and is about one-sixteenth of its distance from *Theta*." Mr. Lassell's note at the time in his journal states "about five-eighths of the distance of the sixth star from *Theta*." On referring to his original communication, it appears that the distance there mentioned was *six-tenths*, which was inadvertently printed as *one-sixteenth*.

On the Missing Nebula in Coma Berenices. By M. Chacornac.

(*Extract of a Letter to Sir J. Herschel, dated Paris, 22d May, 1862.*)

"Permettez moi de vous adresser quelques renseignements sur la nébuleuse variable dont vous annoncez la disparition dans le No. 6 du xxii^{me} volume des *Monthly Notice*.

"Le 19 Avril dernier, ayant dirigé le grand télescope de M. Foucault sur la région du ciel environnant l'étoile (6) de la constellation de la chevelure de *Bérénice*, dans le but d'étudier la structure des nébuleuses qui s'y trouvent condensées; j'y remarquai une nébuleuse double dont l'une des deux composantes avait un éclat bien plus faible que l'autre, ce qu'il était facile d'apprécier par leur visibilité dans le même champ de vue.

"En dirigeant de nouveau le même instrument sur le lieu que vous désignez, j'ai reconnu que les trois nébuleuses cataloguées se trouvent à peu près à leur place respective que vous indiquez. Les deux objets (A) et (B) sont bien de première classe et une étoile de dixième à onzième grandeur précède bien la nébuleuse (B) de 24^s, mais je trouverais une différence d'ascension droite moins grande entre ces deux objets, c'est à dire :—

$$\text{R.A. (B)} - \text{R.A. (A)} = 13^{\text{h}}5.$$

"La troisième nébuleuse peu éloignée de (B) est bien celle que j'ai aperçue le 19 Avril; elle répond assez bien aux différences que vous annoncez mais elle brille d'un faible éclat. Sa constitution analogue à celle de (B) m'a permis de comparer son intensité lumineuse à celle de cette nébuleuse au moyen d'un micromètre à double image appliqué au télescope; j'ai trouvé ainsi la lumière du compagnon quatre fois plus faible que celle de la nébuleuse principale (B)."

Mr. Rümker has presented to the Society the manuscripts containing his Observations of Southern Stars made at Paramatta in the years 1826 and 1827. The thanks of the Council were voted to him for this valuable gift. •

On Heliotypography. By Warren De La Rue, Esq.

The accompanying print of Sun-spots was produced from a collodion negative, taken by means of my Newtonian reflector of 18 inches aperture and 10 feet focal length, on the scale of 3 feet for the Sun's diameter.

The original focal image was enlarged before reaching the sensitive plate from about 1 inch in diameter to the scale of the picture, by means of a new combination of lenses which projects the image without sensible distortion on a flat field, and whose visual and chemical foci coincide perfectly.

The camera which is attached to the eye-end of the telescope will hold a plate 18 × 18 inches, so that about one-fourth of the Sun can be depicted at one time. Even for a picture of such a size, the apparatus is very heavy, and could not be carried safely at one end of the tube, unless a provision had been made to support it. This is effected by means of a radius bar, which moves on a short independent axis, fixed on the framing of the telescope, in the prolongation of the polar axis.

When Sun-pictures are taken, the telescope tube is for convenience rotated in its cradle through an arc of 90° from its ordinary position, so as to place the eye-piece underneath. To the sliding tube which carries usually the eye-piece, is fixed the instantaneous apparatus, which moves in a direction at right angles across the tube. The moveable plate of the instantaneous apparatus slides as nearly as possible in the plane of the primary focal image.

The enlarged image is received at a distance of about 4 feet from the secondary magnifier.

The printing block was produced by M. Paul Pretsch, according to a method he has invented. The process may be rendered sufficiently clear without revealing the exact process, which he does not wish to disclose at present.

Gelatine is mixed with a salt of chromic acid, such as bi-chromate of potash, and poured on to a glass plate, and allowed to dry in the dark. If a plate so prepared is exposed to light, and a similar plate is retained in the dark, and the two plates are subsequently moistened with water, it will be found that the gelatine which has not been exposed to the



Figure 1. The culture supernatant of *Escherichia coli* infected with bacteriophage T4. The large, dark, elongated structure is a bacteriophage. The smaller, dark, irregularly shaped particles are other phages or debris.



action of the light will swell up like ordinary gelatine, while that which has been exposed to light will have become changed, and will remain unacted on by the water.

If, therefore, an ordinary negative be placed over the dry prepared film of gelatine, and both are submitted to the action of light, the gelatine will become more or less changed in proportion to the intensity of the light transmitted through the several parts of the negative. For example, in the case of a negative of a Sun-spot, much light will pass through the image of the spot, less through that of the penumbra, and still less through that of the bright parts of the Sun's surface, and the light so transmitted will produce a corresponding hardening of the prepared surface.

When therefore the plate is subsequently moistened, the part corresponding to the spot will remain flat, more or less in proportion to the intensity of light which has acted on it, the bright parts will swell, and the gelatine film will represent the matrix of a surface-printing block.

It is now only necessary to obtain, by means of known processes in electro-metallurgy, a counterpart of the gelatine. The plate so prepared is the printing block, which will furnish many thousand impressions at an ordinary printing-press, it being however necessary from time to time to clear the block, which is liable to become clogged on account of the want of depth in the light parts. On observing the impression at a little distance from the eye, a sort of mottling will be perceived on the bright parts of the picture; this is a true representation of the Sun's surface; on the other hand, an examination of the picture by means of a magnifier will show a vermicelli sort of granulation, which does not belong to the Sun, but results from the process and arises from the change which takes place in the gelatine film passing as it were from the gelatinous or dynamic condition to the crystalline or static condition of matter.

The grain may be made coarser or finer, and need in no way interfere with a picture more than the lines of a steel plate or the grain of a lithographic stone interferes with pictures engraved on the first or drawn on the second.

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MONTHLY NOTICES
OF THE
ROYAL ASTRONOMICAL SOCIETY.

VOL. XXII.

June 13, 1862.

No. 8.

Dr. LEE, President, in the Chair.

David Smith, Esq., Birmingham ; and
John Robertson, Esq., Glasgow,
were balloted for and duly elected Fellows of the Society.

On the proposed Parallax Observations of Mars in 1862.
By Prof. C. Piazzi Smyth.

In the important paper of Dr. Winnecke, of Pulkova, in the *Bulletin* of the St. Petersburg Academy, entitled, "Considerations concernant les Observations Méridiennes à faire pendant l'Opposition prochaine de *Mars*, dans le but de déterminer sa Parallaxe," that able astronomer sets forth — and, as we may assume, satisfactorily — first, the large amount of uncertainty at present existing in the received value of the Solar Parallax (probably $\frac{1}{10}$ th of the whole); secondly, the extreme desirability of improving this determination; and, thirdly, the unusually favourable opportunity which the opposition of *Mars* offers this autumn, beyond and before most of the recent oppositions, for attaining to the desired consummation. He then proceeds to select a series of stars admirably calculated by their position to be compared in declination with *Mars*, each night from August 20th to November 3d, and, finally, to announce that his method of observation will be bisection, or its equivalent, at Meridian transits with a meridian transit-circle.

Now every one knows that whatever may be done at all with a meridian transit-circle will be done by such an instrument at the Central Observatory at Pulkova, with an accuracy which will be an example to almost every country; but yet one may express surprise that in this case a *meridian*-circle should have been chosen; for the object proposed to be immediately gained is, a micrometrical difference only between *Mars* and the stars of comparison, and is therefore more suitable to a large *Equatoreal*, especially as the number of days during which the parallactic effect will be at its maximum is very small, and observations should rather be accumulated at that particular time than thinly spread over many months of smaller parallax.

Of course the intelligent author of the paper referred to has a reason for the opinion he has come to; and it appears to be, firstly, that in so high a northern latitude as Pulkova, measures taken with an *Equatoreal* "at great distances from the meridian, as recommended by Mr. Airy, would be attended with very grave inconveniences;" and, secondly, that he has not been certified that there will be any observations of any kind made at any Southern Observatory.

With regard to the first of these reasons, I cannot say anything with authority; but with regard to the second, it appears to me a duty to one of the absent Astronomers of the South referred to (*viz.* Sir Thomas Maclear, at the Cape of Good Hope), to mention, that I had the honour of receiving from him a letter, towards the end of 1860, detailing his observations of the *Mars* opposition of that year, and describing them with such extraordinary enthusiasm, and looking on them as so essentially his bounden duty, that I at least entertain no reasonable doubt but that he will attend to the opposition of 1862 as honestly and as ably. Furthermore, I should mention—though without any official authority so to do, and subject to correction—that Sir Thomas had made all the observations of 1860 with the 6-inch *Equatoreal* of the Cape Observatory, and expressed himself perfectly delighted with the superior power of that instrument for that purpose (*viz.* measuring micrometrical distances between *Mars* and certain stars near him) over the meridian instruments which he had been obliged to employ on former occasions; and he stated his belief that one night with the said *Equatoreal* was about as good as fifteen nights, I think, with the meridian instruments.

Hence there seems not only a chance amounting to all but certainty, that the *Mars* opposition of 1862 will be observed in the chief Southern Observatory, but that it will be observed with an *Equatoreal* in preference to a meridian instrument; and with this *Equatoreal* the observations will be made—according to the plan of 1860—not so much at great distances from the Meridian, as on and near the Meridian: a position which, it is hoped, will allow the great Pulkova telescope to

be similarly employed, without any of the very grave inconveniences which had been feared for it.

Here terminates, therefore, the first part of the subject; but then immediately forces itself upon our attention this case, whether, granted that the two established Observatories of the North and South fully perform their local parts, is the desired end likely to be obtained—viz. not only an accurate determination of the parallax of *Mars*, but a something so exceedingly accurate that it shall command the attention and elicit the respect of all other astronomers as well, besides those who have assisted at the observations, and to a degree which shall induce them to alter the parallax of the Sun as deduced from the transit of *Venus* in 1769?

In seeking an answer to this requirement, we are met at once by the unflattering circumstance, that oppositions of *Mars* have been observed again and again of late years, and without any such decided step being gained as would warrant an alteration of the received parallax of $8''.5776$. What, then, can be particularly said of the opposition of 1862, that should lead us to expect much better results from it than from its predecessors? This is a point which has not escaped the acuteness of Dr. Winnecke; and he accordingly mentions—besides previous observations North and South not being very comparable—that the planet itself was not on those occasions at its least terrestrial distance, which it will be very nearly at in 1862, “or only 0.4 from the Earth, the Earth’s mean distance from the Sun being 1.0.”

In referring to the *Nautical Almanac*, however, it appears that whereas the parallax of *Mars* will be $21''.2$ on Sept. 28th, 1862, it was no less than $21''.9$ on July 20th, 1860; consequently the opposition of that year was more favourable in so far by $\frac{1}{3}$, and constituted, therefore, the season when all the observations concerned should have been working for the parallactic difference, rather than in 1862. The Northern Astronomers were, however, hindered in their part of the scheme by their joining the eclipse expedition to Spain—the eclipse occurring on the 18th July, and the *Mars*’ opposition observations extending over June, July, and August. This appears to give some excellent hints; for, if many *Mars* observations were lost on that occasion, it has been allowed on the other hand by all persons, that the eclipse gained immensely by the said expedition; and, in truth, expeditions are not only most powerful means for making the most of any special astronomical phenomenon, but they have never yet had full scope given to them; although their results have been, in almost every case when they have been tried, successful. What for instance, it may be asked, would have been the transit of *Venus* in 1796, but for the numerous geographical expeditions that were fitted out to observe it from special and peculiar points of the earth’s surface? To this question

we would hardly answer, "Nothing," but rather, "A something so little accurate, that it would have yielded long since to very ordinary *Mars*' opposition observations."

If, then, the *Venus*' observations were, by astronomical expeditions, rendered so much more powerful for their useful end than they otherwise would have been, why should not the *Mars* observations receive the same auxiliary aid? The weaker astronomical phenomenon (for getting at the Solar parallax) surely needs all the more geographical magnifying of the effect, if its result is to be used in correcting the conclusions of the other. But if this magnifying be not done, then, no matter what result the present fixed Observatories arrive at, they will inevitably *not* be considered by the astronomical world to have settled the parallax of *Mars*; for they so plainly leave an opportunity to some one else, only a couple of years after, to make the same observations from a notoriously better base-line.

Had the observations been necessarily to be taken with a meridian circle, and necessarily to have occupied about three months, there might have been some reason for leaving the matter to fixed and established stations; but when they are more naturally to be made with an Equatoreal, as being small differences only, and might all be comprised most profitably within ten days or a fortnight, they come legitimately within the compass of astronomical expeditions; and, viewed in that light, the opposition of 1862 has this decided advantage over that of 1860, that it occurs at an equinoctial season of the year, when the light and heat circumstances of stations in high latitude both North and South will be very nearly similar.

In fact, at that season of the year and for the limited period demanded by equatoreal observations, there would seem to be no reason why an observer should not be sent to the North Cape, latitude $+71^{\circ}10'$, and another to the southernmost island of Cape Horn, latitude $-55^{\circ}48'$, and thus observe with an intervening difference of 127° , in place of 94° only, the angle between Pulkova and the Cape.

There is little time left now to arrange such expeditions; but we often find, that it is precisely the shortness of time given wherein to perform any work, which calls out men's energies in accomplishing it; and, in such a point of view, there may be still quite time enough. On the understanding, too, that measures on, and near, the meridian, will be made at both stations, rather than at great hour-angles, a very portable folding dome, like Capt. Jacob's, might be easily arranged to allow of limited openings in definite directions, combined with full security to the instruments from inclement weather; and if only a week, indeed only three fine nights, could be secured about the time of maximum parallax, a remarkable micro-metrical result might be obtained, and such a one as has not yet been seen in the history of Astronomy; obtained, too, not by anything so costly as what is usually called an expedition,

for the whole thing would rather partake of what the French would term "*une promenade astronomique*."

Even this time, too, might perhaps be shortened, and the result improved, by supplementing the hand-micrometer measures, with photographic pictures of *Mars* and the neighbouring stars, taken in the field of the telescope at intervals through the night on collodion plates, and submitted to screw and microscope measurement on returning to this country.

Royal Observatory, Edinburgh,
June 12, 1862.

*Extract of a Letter from M. Winnecke to the Rev. R. Main,
dated Pulkowa, 1862, May 30.*

"I had the pleasure, a few days ago, to send you a short notice, in which a common plan of action is recommended for the observations of the approaching opposition of *Mars*. You, equally with myself, will be impressed with the importance of the questions at issue; and you will, I hope, at the same time, in looking through my proposals, see that they have not been made without mature consideration of the circumstances. I venture therefore to request that you will use your authority to set on foot, as far as possible, for the approaching opposition, a system of co-operation in relation to meridian observations of declination of *Mars*.

"I add here a few short remarks on some Variable Stars, which you will probably find an opportunity to communicate for the *Monthly Notices*.

"In No. 2, vol. xxii., of the *Monthly Notices*, which I received some weeks ago, Mr. Knott draws attention to the variable star R *Vulpeculæ* = *Piazzi*, xx. 457. The minimum is, according to his estimations, nearly coincident with a predicted maximum. In Pogson's Ephemeris my name is given as the authority for the time of maximum. I did certainly, two years ago, communicate to Mr. Pogson elements of this star; but I was afraid that an error of transcription had crept into them. My elements, which represent seven maxima, observed in the course of three years, with reference to *Piazzi*'s estimations of magnitude, in August 1803, are namely

$$\text{Maximum, 1860, Nov. } 6 + 1384.6 n$$

(n being the number of periods from 1860, Nov. 6);

from which the maxima of 1861 fall on March 25, August 10, and December 27, and those next to be expected should occur on

1862, Sept. 30; 1863, Feb. 18, July 4, Nov. 20.

"I take this opportunity to communicate the following approximate first elements of some other stars, for which no data are given in Pogson's Ephemeris:—

T Virginis. 1860·0, $\alpha = 12^h 7^m 26^s$; $\delta = -5^\circ 15' 5''$.

Variable from the 8th mag. to less than the 13th.

Maximum, 1862, April 12 + 337^d n.

The next maxima, 1863, March 15; 1864, Feb. 15.

T Ursæ Majoris. 1860·0, $\alpha = 12^h 30^m 1^s$; $\delta = +60^\circ 15' 5''$.

Maximum, 1860, Oct. 31 + 257^d n.

Variable from 6·7 mag. to less than the 13th.

The next maxima, 1862, Dec. 11; 1863, August 25.

R Camelopardali. 1860·0, $\alpha = 14^h 28^m 28^s$; $\delta = +84^\circ 27' 9''$.

Maximum, 1861, August 17 + 265^d n.

Variable from 7th mag. to 13th

The next maxima, 1863, Jan. 29, Oct. 21.

S Cygni. 1860·0, $\alpha = 20^h 2^m 34^s$; $\delta = +57^\circ 35' 0''$.

Maximum, 1861, Dec. 24 + 324^d n $\pm$.

Variable from 9th mag. to less than 13th.

The next maximum, 1862, middle of November.

S Cephei. 1860·0, $\alpha = 21^h 36^m 54^s$; $\delta = +77^\circ 59' 6''$.

Minimum, 1862, Feb. 1 + 470^d n $\pm$.

Variable from 8·9 mag. to 11·12.

The next minimum, 1863, May.

"The elements of this last star are little to be relied on, on account of the great difficulty of observing the blood-red variables. It appears, like *T Cancræ*, to remain very long at its maximum, and to change its light slowly. For *S Leonis* (as the star at $\alpha = 11^h 3^m 36^s$, $\delta = +6^\circ 13' 2''$, ought to be called, since a star formerly so called is still not proved to be decidedly variable), the following elements will be somewhat more accurate:—

Maximum, 1860, Dec. 24 + 192^d n.

The next maxima, 1862, July 23; 1863, Jan. 31.

Disappearance of B.A.C. 4923 at the Moon's Dark Limb, 1862, June 9, observed at the Radcliffe Observatory, Oxford. By the Rev. R. Main.

The star is a double star, the components being of about the 6th and 9th magnitudes. The time of disappearance of each star was instantaneous, and the observations were very good.

Sidereal time of disapp. of smaller star	...	...	h	m	s
			15	22	44.53
" " larger "	...	...	15	23	14.03
Oxford mean time of disapp. of smaller star	...	...	10	10	40.03
" " larger star	...	...	10	11	9.45
Greenwich mean time of disapp. of smaller star	...	...	10	15	42.63
" " larger star	...	...	10	16	12.05

This star deserves the attention of astronomers, as, in addition to its duplicity, it has a large proper motion of $+0^{\circ}.068$ in R.A., and of $+1''.68$ in N.P.D.

I observed the distance and angle of position of the components of the double star on May 19, 1862; and I found for the distance (mean of six measures) $13''.51$, and for the angle $283^{\circ} 51'$.

By comparison with Smyth's measures (*Cycle*, vol. ii. p. 329), it would appear that (unless he is in error) the star has been changing very rapidly both in distance and position-angle.

Observations of Jupiter's Satellites and of Saturn's Ring: Occultation of a Star by the Moon. By C. G. Talmage, Esq.

I send four observations of *Jupiter's* Satellites made at Nice, and three made at Mr. Coventry's Observatory, 5 Tavistock Square, and also an extract from my note-book concerning the peculiar appearance of *Saturn's* ring, about which so much has lately been said.

Occultation: Disappearance of Jupiter's First Satellite.

1862, March 17.

	h	m	s	
First contact	7	55	4	Nice M.T.
Central bisec.	7	56	39	"
Total immersion	7	58	43.5	"

Transit : Egress of Jupiter's First Satellite.

1862, March 13.

First appearance	^h 7 ^m 20 ^s 56	Nice M.T.
Central obsc.	7 25 20	"
Last contact	7 29 49	"

8

Eclipse : Reappearance of Jupiter's Second Satellite.

1862, March 14.

11^h 55^m 53^s·74 Nice M.T.

The time noted is exact; the satellite very distinct and beautifully defined; there appeared a great rupture in the southern belt near the centre, of a pyramidal shape, and a much darker colour than any other part of the belt.

Eclipse : Reappearance of Jupiter's First Satellite.

1862, March 24.

12^h 13^m 10^s·90 Nice M.T.

The satellite rather faint.

Latitude of Nice = 43° 41' 45" N.

Longitude ditto = 29° 7' E.

Nice, February 24, 8^h, 1862.

The night was not very fine, although *Saturn* appeared very distinct, and the peculiar marking on the ring was well defined, presenting a double serrated edge, with a distinct black line between the upper and lower edges; and the body of *Saturn* had, if I may use the expression, a dirty look. I only mention this, as I have not seen any observations of the kind prior to the above date, which I think shows that we are favoured with a very fine atmosphere, to see that peculiarity in our small glass.

Occultation : Disappearance of Jupiter's Second Satellite.

1862, May 2.

8^h 58^m 22^s·30 G.M.T.*Eclipse : Reappearance of Jupiter's First Satellite.*

1862, May 2.

10^h 12^m 8^s·30 G.M.T.

Astronomer Royal, Observations of Minor Planets. 289

Eclipse: Reappearance of Jupiter's Second Satellite.

1862, May 20.
8^h 21^m 49^s.80 G.M.T.

Latitude of Tavistock Square Observ^y. 51° 31' 30" N.
Longitude ditto : 0^h 0^m 29^s.7 W.

Mr. Talmage sent also the following observation,

Occultation: Disappearance of B.A.C. 4923, June 9.

This is a very fine double star of the 6th and 8th magnitudes. The following are the noted times of disappearance:—

Small star, 8th mag. 10^h 17^m 24^s.50 G.M.T.
Large star, 6th mag. 10^h 17^m 52^s.30 "

At the time of reappearance, a thin cloud hid the small star, but the larger one came out sharp and well defined, instantaneously at

11^h 29^m 7^s.00 G.M.T.

Results of Meridional Observations of Small Planets, and Phenomena of Jupiter's Satellites; observed at the Royal Observatory, Greenwich, during the month of May, 1862.

(Communicated by the Astronomer Royal.)

Hebe (6).

Mean Solar Time of Observation.		R.A. from Observation.	N.P.D. from Observation.
	^h ^m ^s	^h ^m ^s	^o ['] ["]
1862, May 12	13 36 58.6	16 59 12.55	90 40 15.52
20	12 59 4.9	16 52 45.10	90 12 48.56
31	12 5 37.0	16 42 30.58	89 53 9.54

Flora (8).

Mean Solar Time of Observation.		R.A. from Observation.	N.P.D. from Observation.
	^h ^m ^s	^h ^m ^s	^o ['] ["]
1862, May 5	10 38 38.6	13 32 47.41	89 44 50.77
19	9 33 56.7	13 23 6.65	89 25 36.17
30	29 29.5	13 22 35.25	89 25 37.88

Melpomene (10).

Mean Solar Time of Observation.			R.A. from Observation.	N.P.D. from Observation.
	^h	^m ^s	^h ^m ^s	[°] ['] ^{''}
1862, May 16	11	15 24.6	14 53 1.57	90 18 6.91
19	11	0 53.2	14 50 17.46	90 8 1.20
20	10	56 3.7	14 49 23.72	90 4 58.46

Massilia (30).

Mean Solar Time of Observation.			R.A. from Observation.	N.P.D. from Observation.
	^h	^m ^s	^h ^m ^s	[°] ['] ^{''}
1862, May 12	12	35 23.6	15 57 27.77	109 53 30.07

Euterpe (7).

Mean Solar Time of Observation.			R.A. from Observation.	N.P.D. from Observation.
	^h	^m ^s	^h ^m ^s	[°] ['] ^{''}
1862, May 5	10	15 13.9	13 9 18.80	94 51 28.60
20	9	9 4.3	13 2 6.71	94 21 36.86

All the observations of N.P.D. have been corrected for Refraction and Parallax.

No Occultations of Stars by the Moon were observed.

Phenomena of Jupiter's Satellites.

Day of Ob- servation. 1862.	Satellite.	Phenomenon.	Mean Solar Time. ^h ^m ^s	Observer.
May 2	II	Occ. disapp. first cont.	8 55 2.0	D.
"	II	" bisection	8 56 47.0	D.
"	II	" last cont.	8 58 47.0	D.
"	I	Eclipse, reappearance (a)	10 12 23.3	D.
17	I	Egress, bisection	10 14 48.0	C.

(a), Very hazy; the observation not very satisfactory.

The initials D. and C. are respectively those of Mr. Dunkin and Mr. Criswick.

Description of a New "Aplanatic" Eye-piece for Telescopes.
By T. W. Burr, Esq.

Those astronomers who are also microscopists are probably acquainted with an eye-piece for the microscope known as "Kellner's," or the "Orthoscopic," which offers the advantage

of a much larger field of view than the Huyghenian of corresponding power, and with equally good definition. It consists of a double convex crossed lens for field glass (that is, a lens having surfaces of different radii, the most convex side being towards the objective), and a meniscus of great convexity and small concavity for eye-glass. There is no stop in this arrangement.

Having experienced the benefit of this construction with the microscope, I was desirous of applying it to the telescope; and while trying the "Kellner" belonging to my microscope on the telescope of my Equatoreal, with which it produced only a low power, and when about to have another made for the purpose, I was informed that Mr. Thornthwaite (of the firm of Horne and Thornthwaite, Newgate Street,) had improved the "Orthoscopic" microscopic eye-piece, by substituting an *achromatic* plano-convex lens for the meniscus. The eye-glass, in his modification, consists of a double convex crown-glass lens and a plano-concave of flint-glass, forming a combination similar to one of the pairs of an achromatic microscope objective; and this construction (the field-glass remaining a crossed double convex) preserves the advantage of the large and flat field; with better definition and freedom from colour, which has induced the inventor to call it the "Aplanatic" eye-piece.

Having used this form in a microscope, I at once decided to adopt it for my telescope experiments; and therefore requested Mr. Thornthwaite to make me a suitable eye-piece, which, for the purpose of comparison, I required should be of the same power as my third Huyghenian, which, measured by Ramsden's Dynameter, gives with my object-glass a power of 123. The new eye-piece constructed for me, measured in the same way, gives 125 for its power,—a sufficiently close approximation; the slight difference being against the new combination as to size of field.

I have submitted this eye-piece to a careful and lengthened trial, and can now confidently recommend it to observers, as possessing the very great advantage of a much increased field, as compared with the Huyghenian of the same power. This is at once evident on looking at the Sun or Moon, when at least one-third more of the disk of either body is visible with this eye-piece, than with the corresponding Huyghenian. For instance, with my telescope and the ordinary eye-pieces; while a power of 60 includes the whole disk of either Sun or Moon, 80 fails to do so; and with 123 on the Moon, the field includes from the South Pole to about *Plato*, or from the North Pole to near *Bullialdus*, or in longitude, from the eastern border to *Copernicus*: while with the "Aplanatic," of even a little more power, the merest film of one edge is left unseen, and on one favourable occasion, the full Moon was entirely included. The

definition is also quite equal to the Huyghenian at all parts of the field.

The benefit of this eye-piece is also strikingly apparent in viewing clusters, such as the *Pleiades*, *Presepe*, and others; in which small stars are brought up by the increase of power and light, without losing the advantage of a large field; and in the Great Nebula of *Orion*, the effect is very beautiful, allowing the employment of a power which before was disadvantageous, as it made the object dim, and contracted the field; which is now large, and the nebula very brilliant. The division of double stars is rendered easier by this eye-piece, and the range of the telescope among small ones extended. For example, persons who could not see *Lyra* quadrupled with the Huyghenian of 123, had no difficulty in doing so with the Aplanatic, while the detail of the planets, and generally every object, is more readily appreciated.

I send herewith sketches of the construction of the three forms of the eye-piece, viz. the Huyghenian, Kellner's, and the Aplanatic, for comparison; and also place the instruments themselves before you.*

Highbury, June 10, 1862.

On the Appearance of Jupiter without a Visible Satellite,
Sept. 1843. By the Rev. W. R. Dawes.

It has been lately suggested to me by the Astronomer Royal, that a remarkable phenomenon, which I happened to observe many years ago, ought to be recorded where it might be readily referred to; and that in fact there could not be a more suitable repository for it than the Royal Astronomical Society. I have much pleasure in acting upon this suggestion, being assured that no other apology can be needed for offering to the Society an observation which was made nearly nineteen years ago. I refer to the appearance of *Jupiter* without a visible satellite in September 1843. The observation of this rare phenomenon was immediately afterwards communicated to *The Times* newspaper in a letter, which principally referred to another Jovian phenomenon, namely, the dark transit of one of his satellites. I supposed at the time that the solitary appearance of *Jupiter* would be extensively observed; and that many communications would be made to the Society by observers possessing the means of more accurately noting the *times* of the

* The sketches and instruments were exhibited at the Meeting of the Society.—Ed.

different occurrences than I happened to have on that occasion. Had I been aware that not a single notice of it would be sent to the Society, I should certainly have made a communication, though in some respects imperfect, in time for the first meeting of the then ensuing session. I mention these circumstances as furnishing the only apology I can offer for having omitted to send some account of the observation to the Society immediately.

On 1843 September 27, in the early part of the evening, *Jupiter* appeared with all his four satellites very near him, and all approaching him. The *fourth* satellite passed on to the disk soon after 8^h 30^m G.M.T. This I observed at Mr. Bishop's observatory, with his equatoreal refractor of 7 inches aperture, by Dollond. At about 9^h 50^m I again directed the telescope to the planet, which very soon afterwards passed behind a tree; and as the state of the air was too unfavourable for observations of double stars, in which I was almost entirely occupied, I repaired to my own residence in Park Place, and turned upon the planet a very excellent 43-inch refractor of 2.7 inches aperture by Dollond, power 113.

Soon after 10^h G.M.T. (time not exactly noted) the *first* satellite passed on to the disk of *Jupiter*.

At 10^h 35^m $\pm$ the *second* satellite was occulted.

At 11^h 55^m $\pm$ the *third* satellite passed on to the disk.

Jupiter was then without a visible satellite.

At 12^h 30^m $\pm$ the *first* satellite passed off the disk.

At 13^h 30^m $\pm$ the egress of the *fourth* satellite occurred.

It appears, therefore, that for about an hour and twenty minutes the *third* satellite was the only one visible. For about thirty-five minutes *Jupiter* was without any visible satellite. And after the egress of the *first* satellite it was the only visible attendant for rather more than an hour.

The uncertainty of the times specified arises from the fact, that those which were noted at all at the instant of the occurrence, were taken from a pocket-watch, the precise error of which was unknown. And in one instance, the time was estimated from the supposed interval which had elapsed between the occurrence of the phenomenon and the procuring of a light, which was not at hand at the instant. It was this uncertainty which deterred me from presenting to the Society an account of the observation, hoping that others would be presented containing details as to time more accurately noted.

Hopefield Observatory, Haddenham, Thame, May 1862.

On the Periodical Changes in the Belts and Surface of Jupiter. By W. Huggins, Esq.

In addition to the ceaselessly varying appearances of the surface of the planet *Jupiter*, there would seem to be great periodic changes occurring in the conditions on the planet, of whatever nature those conditions may be, which give rise to the phenomena visible to us. It would seem therefore to be of considerable interest to bring together for careful comparison drawings of *Jupiter*, exhibiting in sufficient detail the more remarkable of the forms which the belts and spots assume at different epochs. For example, the comparatively inactive state of the planet during 1858 and 1859, contrasts in a very marked manner with the strongly defined and actively changing dark belts of the present year. In the hope of exciting attention to these periodical changes of *Jupiter's* surface, and as a humble contribution towards the commencement of such a series of representations of *Jupiter*, I have sent herewith a few drawings, exhibiting in considerable detail, and I believe, with great fidelity, the more characteristic of the appearances of *Jupiter* during the seasons of 1858, 1859, and 1860.* Object-glass 8 inches diameter, and power from 150 to 400.

Upper Tulse Hill.

Transit of Titan's Shadow. By S. Gorton, Esq.

Mr. Dawes' account, in the last number of the *Monthly Notices*, of this interesting phenomenon on the 15th of April, concludes by stating that, in his opinion, "from the great size of the shadow, a 5-foot refractor of $3\frac{1}{2}$ to 4 inches aperture would have shown it."

This is completely verified by my observation of the same evening, a short notice of which was read at the meeting of the Society on the 9th May. My telescope is of 4 feet focal length and $3\frac{1}{8}$ in. aperture. I observed with a power of 170, and afterwards with one of 100. At the time I left off observing, the shadow of *Titan* was near the centre of the disk of *Saturn*, and was almost as easy to be seen with the latter power as one of the shadows of *Jupiter's* satellites in transit.

Downs Road, Clapton, June 19, 1862.

* The drawings were exhibited at the Meeting.—ED.

*On the Appearance of Saturn's Ring, 1862, May 13, 8^h 45^m
G.M.T. By W. R. Birt, Esq.*

On the evening above specified I had an opportunity of observing *Saturn* at this interesting epoch, with an 8-inch object-glass, which Mr. Slater is now constructing for T. Coventry, Esq., and also with the large refractor of nearly 15 inches aperture.

The state of the atmosphere was not over favourable for so delicate an observation, nevertheless, during fits of good definition, which were not of long duration, I saw very distinctly the fine ansæ broken into minute points or beads of light. It was difficult to get a sufficiently steady interval to count these beads, but the impression I had as to the number of the most prominent was that there were about seven, four on the following and three on the preceding ansa; Mr. Slater noticed five on the following ansa. The following ansa was the longest. On one occasion I obtained a very fine view, when they appeared as *irregularities or projections on the illuminated plane of the ring*, as if such projections were more directly illuminated, and consequently reflected more light than the obliquely illuminated plane of the ring. I did not obtain a confirmation of this interesting appearance. The ring of the shadow formed a somewhat narrow dusky line across the disk, the northern portion being rather the darkest. Mr. Talmage, who was present, saw the fine line of light separating the two, but when I inspected the planet the atmosphere was not sufficiently fine to allow me to witness this interesting phenomenon. Mr. Slater, who observed the beads with a 10-inch object-glass on the 8th of May, at Sheffield, witnessed the phenomena above described, the only exceptions being the number of beads on the following ansa, and the number on the preceding, which he did not estimate.

On the 1st of May Mr. Slater witnessed the transit of the shadow of *Titan* across the disk of the planet.

On some Phenomena attending the Disappearance of Saturn's Ring, May 19th, 1862. By W. Huggins, Esq.

The following notes may perhaps be of some value in support or otherwise of more complete observations of *Saturn*, during a period of so much interest as that through which the planet has just passed.

May 2d. A brief separation of the clouds showed *Saturn* with two bright dots of light upon the eastern ansa of the ring. These were at first taken for satellites. As the haze thickened

and the ansæ faded from view, the contrast between these bright points and the fading ring increased until the ring was lost, when the dots of light alone continued visible as faint and badly defined satellites. As there were no satellites near these positions on that evening, these appearances corresponded probably to the "bright points" seen on former occasions. Vide *Monthly Notices*, vol. x. p. 47.

May 12th. The points of light were again faintly visible, and were best seen when the eye was not directed to them. Passing masses of haze brought them out in strong contrast with the ring, as the pale light of the ansæ seemed to suffer greater diminution in proportion than the brighter points.

May 13th. On this evening they were distinctly traced on the eastern ansæ to correspond in position with the inner and outer edges of the extremity of the ring. One was seen at the termination of the dark space between the ball and the ring, and the other at the extremity of the visible portion of the ring.

On the 16th the ansæ still continued steadily visible, but no indication of these bright points could be seen. The colour of the ansæ, that is, of the surface of the ring seen very obliquely, was a deep bluish purple. A badly defined line of faint shading was suspected across the ball close to the southern edge of the projected ring, in the position in which the shadow of the ring was looked for.

Since that date up to this time, June 10th, no trace whatever of the expected shadow of the ring upon the ball can be detected, though carefully searched for.

On the 17th, 18th, and 19th of May, the ansæ were still seen, though with increasing difficulty, and therefore never totally disappeared.

On the 20th the ansæ appeared of a beautiful dark blue colour, scarcely distinguishable from the dark blue of the sky, which contrasted strongly with the yellow light of the ball.

Upon several occasions, May 18th especially, little roughnesses, resembling miniature satellite-shadows, were suspected on the southern edge of the ring upon the ball, but in every instance these disappeared entirely with the employment of powers from 600 to 950. With these powers, in moments of best vision, the edge of the ring was seen perfectly even and unbroken.

May 17th was cloudy, but at 11^h 30^m the shadow of *Titan* was seen projecting rather more than half its diameter from the northern edge of the ring.

June 2d. The weather was equally unfavourable; at 10^h 45^m a brief separation of the clouds showed *Titan's* shadow in contact with the southern edge of the projected ring.

Object-glass 8 inches diameter. Power from 200 to 950.

June 11, 1862, Upper Tulse Hill.

Saturnian Phenomena. By the Rev. W. R. Dawes.

The night of May 17 was remarkably favourable, especially the earlier part of it, and afforded a very fine view of the expected transit of the shadow of *Titan* across the disk of *Saturn*.

Previously to the ingress of the shadow, I examined the planet most carefully with a power of 620 on my $8\frac{1}{4}$ -inch object-glass, which, when twilight had sufficiently faded, was well borne—the features of *Saturn* frequently coming out with beautiful distinctness, and the edge of the disk being sharply defined. The arms of the ring were scarcely at all visible; a very faint gleam of coppery light, at moments of finest vision, being the only indication of its existence beyond the disk of the planet. It has since been seen, on several occasions, much more plainly. On the disk the projected ring appeared as a very dark line a little north of the equator, and of uniform breadth. But I was much surprised that, under the finest definition with this high power, I could discern no trace of the *shadow of the ring*. I expected to see it, if the atmospheric circumstances were sufficiently good, as an *exceedingly fine black line*, stretched across the disk about a quarter of a second to the south of the inner edge of the projected ring; and that the shadow of the satellite would travel almost centrally on the black line—a great part of it, however, falling on the southern portion of the ring. But no such thing was to be found.

Having applied the parallel-wire micrometer with a power of 480, with which the planet was usually very sharply defined; as the expected time of ingress approached, I kept my eye steadily fixed on the eastern extremity of the dark line caused by the projected ring.

At 9^h 35^m G.M.T., the end of this dark line was observed to be decidedly enlarged, especially on its *northern side* (instead of the *southern*, as was expected).

At 9^h 37^m, the shadow was judged to have just completed its ingress.

At 9^h 40^m, a narrow thread of light was perceived outside the shadow, and on the northern side of the projected ring. It then became obvious that the shadow projected rather more than half its diameter to the *north* of the ring, and so little to the *south* of it that only under the finest views could any projection on that side of it be certainly perceived.

At 9^h 52^m, I carefully estimated that six-tenths of the diameter of the shadow projected from the northern edge of the ring.

After this time the state of the air greatly deteriorated, and I obtained with difficulty some micrometrical measures with powers 375 and 286. The result gave the distance of

the satellite from its shadow in the direction of the axis-major of the ring = $16''.06$.

At $12^h 10^m$, the shadow was judged to be in the middle of its transit, as determined by the webs of the micrometer.

The difference in the degree of darkness of the ring projected on the ball, and of the shadow of the satellite which fell upon it, was more striking than I expected. The ring looked like a line drawn with a good BB *lead-pencil*; the shadow resembled a *spot of ink*.

The position of the shadow with respect to the ring seems conclusively to prove that *Titan*, in that part of his orbit, is somewhat to the *north* of the plane of the ring, with which, therefore, the plane of his orbit is not absolutely coincident. This, indeed, seems to be the case with some of the interior satellites also.

The synodic period of *Titan*, computed from the observed transits of April 15 and May 17, comes out = $15^d.967014$, from comparison of the times of complete ingress, and = $15^d.966667$ from comparing the times of the shadow's attaining a central position; the mean of the two being = $15^d.96684$. The period calculated from the actual orbital motion of the planet, and assuming the sidereal period = $15^d.94543$, results = $15^d.96967$; the difference amounting to about four minutes.

Nothing, I imagine, can more fully prove the *almost inconceivable thinness of the ring* than the absence of all perceptible shadow. Had it even the least thickness which has ever been ascribed to it (namely, forty miles, by Mr. G. P. Bond, Director of Harvard Observatory, at Cambridge, U. S.), it would be sufficient to produce a total eclipse of the Sun on *Saturn's* equator, as it would subtend an angle more than double that subtended by the disk of the Sun as seen from *Saturn*. This fact seems to me powerfully to support the conjecture which I threw out in my paper on the disappearance of the ring in 1848 (see *Monthly Notices*, vol. x., p. 46), as capable of accounting for the visibility of the ring when its unenlightened surface is turned towards the Earth, namely, *the existence of a pretty damp atmosphere on the rings*; through which the refraction of the light of the Sun, when nearly in the plane of the ring, would throw a pretty strong *twilight* upon them; and this would not only produce a slight degree of copper-coloured illumination upon the surface of the ring, but would also reduce the *shadow* of the ring on the ball to a slight *penumbra*; the *refracted light* from both surfaces of the ring, when the sun is nearly in its plane, being sufficiently strong to render the shadow of so thin a substance, as the ring undoubtedly is, quite undistinguishable.

On May 25 I observed, under sadly unfavourable circumstances, an *immersion of Titan in the shadow of Saturn*. The

state of the air was deplorably bad, and the planet was low at the time of the immersion. The light of the satellite gradually faded, until it was much less than that of *Dione* (then near its eastern elongation), and at last could only be certainly seen during the brief periods of more tranquil vision. The last of these occurred at about $12^h 30^m$ G.M.T.; and at the next tolerable view, which occurred at $12^h 33^m$, the satellite had totally disappeared.

Had the planet been near the meridian, and the air in a good state, I believe the observation might have been made with a considerable degree of certainty. It may be hoped that the excellent opportunities which have lately occurred of observing the Saturnian phenomena in America will not have been neglected.

I am not acquainted with any other observation of an eclipse of this satellite; and it is the first which I have been able to see, though constantly on the watch for it near the times of the disappearance of the ring in 1848, and in the present year.

On June 2, the shadow of *Titan* again transited the disk of *Saturn*. The sky was most unfavourable; yet a tolerable view of the planet, at about $8^h 50^m$ G.M.T., showed the shadow notching the eastern edge; and at $8^h 55^m$ the shadow had completed its ingress. When it had advanced some way on the disk, I carefully estimated that it projected about as much from the *south* side of the ring, as seen on the planet, as on May 17 it projected from the *north* side of it. Highest useful power, 296. Before the shadow arrived at the middle of its transit, clouds completely covered the sky.

The comparison of the times of ingress, on May 17 and June 2, gives the synodic period $= 15^d.97500$, being about $1^m 40^s$ greater than the calculated period.

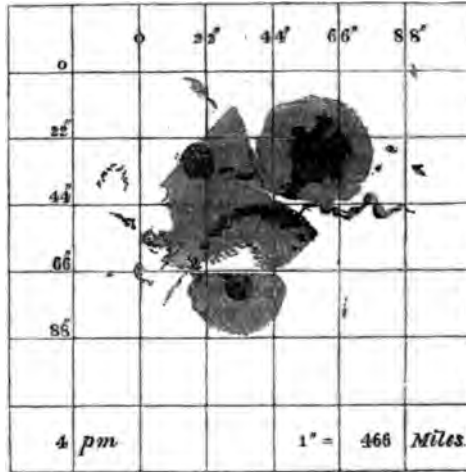
Hopefield Observatory, Haddenham, Thame,
1862, June 10.

June 11. The eclipse of *Titan*, last night, was lost through clouds.

On a Solar Spot. By R. Hodgson, Esq.

The large group of spots which has passed across the Sun's disk during the last fortnight was so peculiar in its formation that upon the 8th inst. I made a micrometrical drawing of it. When it first appeared on the Sun's limb, it was a series of circular and nucleated spots, not quite in contact with each other; as it approached the centre of the Sun, they spread out

until nearly in contact; a day or two after, on the 7th, one of the circular spots appeared to be cut in half and obliterated, having a sharp defined edge; on the 8th, a second circle was similarly cut to a straight line, the other half coalescing with a



spot near it; on the 11th I saw it again for a few minutes, when the whole group was much more detached, and, with the exception of the largest spot, the circular character had entirely passed away.

Telescope, 6 inches aperture. Power, 120.

At the close of the evening meeting Mr. Carrington explained and illustrated by diagrams the process which he had lately made use of in obtaining the corrections required by his provisionally assumed elements of position of the solar equator. He stated that 86 series of observations alone were found suitable out of about 1000, which his records comprise, it being necessary to reject the greater part on account of the mutual action of one spot on another in its neighbourhood, and to use only isolated nuclei of small extent and regular form. He showed how the required corrections were deducible from the quantities X and Y , found from an equation corresponding to each observation of the form,

$$\delta - \delta' = X \cos \alpha - Y \sin \alpha,$$

in which δ is N.P.D., found by use of the provisional elements, δ' the true N.P.D., and α the heliographical longitude of the

spots, reckoned along the solar equator from the ascending node. The values of the elements which he has found from the 86 series are

$$I = 7^{\circ} 15' \quad \text{and} \quad N = 73^{\circ} 40' \text{ for } 1850.0,$$

the values of M. Laugier, deduced about 1841, from 26 series, being,

$$I = 7^{\circ} 9' \quad \text{and} \quad N = 75^{\circ} 8' \text{ for } 1840,$$

and those of Dr. Böhm from 19 series being

$$I = 6^{\circ} 57' \quad \text{and} \quad N = 76^{\circ} 46' \text{ for } 1877,$$

The rotation per diem was exhibited in a tabular form for every 5 degrees of declination, as deduced directly from numerous singly determined values in each parallel. The formula

$$865' - 165' \sin \frac{1}{2} \text{ lat.}$$

satisfies the whole so nearly, that although it can only temporarily be regarded as an empirical result waiting for theoretical explanation, it is difficult to see how any improvement in it can be effected as a representation of the numbers. Mr. Carrington claims the term in latitude of the solar rotation as one of the chief results of his long-continued observations of the Sun, the whole of which are nearly ready for the press. It would be anticipating the intended future publication to give more than the bare results in the present place.

In reference to the remarks made in the *Monthly Notices* for February 1862, pages 124 and 125, Mr. Pogson, writing through the Astronomer Royal, desires to make it known that he has undertaken to extend Professor Argelander's noble work southward, by a complete Celestial Survey of the Southern Heavens, as soon as the Variable Star Atlas shall be out of hand. This Survey must, in the first instance, be limited, in its southern direction, by the southern horizon of Madras; but Mr. Pogson looks hopefully to the possibility of ultimately completing it by an expedition to Australia.

Mr. Pogson hopes to begin this work early in 1863; but, he remarks, the limits of time and money, as defined by Professor Argelander's experience, will not apply to a similar work undertaken in an exhausting tropical climate with native assistants.

G. B. AIRY.

1862, June 17.

RECENT PUBLICATIONS.

An Historical Survey of the Astronomy of the Ancients. By the Right Hon. Sir George Cornewall Lewis. London, 1862.

The history of Astronomy has numerous points of contact with the general history of mankind; and it concerns questions which interest a wider class than professed astronomers, for whose benefit the existing histories have been mainly composed. This remark applies with especial force to the early periods of astronomical observation and science. It has in consequence appeared to the author that an attempt might advantageously be made to treat the history of Ancient Astronomy without exclusive reference to physical science, and without any pretension on his part to a profound and comprehensive knowledge of modern mathematical astronomy. As the accounts of Greek Astronomy, though often meagre and fragmentary, afford in general a firm footing to the historian, and enable him to fix with confidence all the principal stages in its progress, it was considered desirable to begin with this branch of the subject, and afterwards to attempt to determine how far the Greeks derived their astronomical knowledge from other nations, and were learners, instead, as was their custom, of being teachers. And, following this plan, the Astronomy of the Egyptians and Assyrians is first discussed in the latter half of the volume. In support of the alleged antiquity of the astronomical science of these empires, appeal is usually made to their primitive civilisation, and their list of kings, reaching through long lines of consecutive dynasties. It became necessary, therefore, to advert to the early history and chronology of these countries, for the purpose of ascertaining how far they serve to prop up the tottering edifice of Assyrian and Egyptian science. And, as may be conjectured, the conclusion of the inquiry is not in favour of the reliability of these accounts; in particular the author's arguments go to throw doubt upon the possibility of reading and correctly interpreting the Egyptian hieroglyphical inscriptions. The origin of Astronomy is sometimes traced to the Phœnicians, whose commercial wants and nocturnal navigation must, it was supposed, have led to a knowledge of the subject: the concluding chapter of the work relates to the navigation of the Phœnicians, their alleged voyages to Britain and the Baltic for tin and amber, and the supposed circum-navigations of Africa. These subsidiary inquiries form not the least interesting part of the volume.

Recherches Astronomiques de l'Observatoire d'Utrecht. Publiées par M. Hoek, Directeur de l'Observatoire et Professeur à l'Université. Première Livraison. 4to. La Haye, 1861. Pp. 1-72.

The work is intended to be a collection of theoretical and practical researches too extensive for an Astronomical Journal, and to be continued at intervals, as the matter presents itself. The present number contains a theoretical investigation of the influence of the motion of the Earth on the fundamental optical phenomena connected with Astronomy—the undulatory theory of light being made use of in the investigation. There are four chapters, relating respectively to Reflexion, Refraction, Aberration, and Astronomical Methods and Instruments; with some additions. One of the conclusions appears to be, that the motion of the Earth produces a sensible modification of the law of refraction.

Die Astronomische Strahlenbrechung in ihrer historischen Entwicklung. Von Dr. C. Bruhns, Astronom der neuen Sternwarte und Professor an der Universität zu Leipzig. 8vo. Leipzig, 1861. Pp. 1-182.

The work relates to Astronomical Refraction, and is divided into two sections—the first containing the history, from the discovery of the phenomenon to the end of the eighteenth century; the second relating to the researches which belong to the present century: the various theories are reproduced, and the mathematical developments exhibited in abridged and simplified forms, with some original investigations. The author proposes to give in a separate treatise the application to observations, and the Tables. There is, at the end of the Preface, a list of the works consulted, which is a convenient *resumé* of the literature of the subject.

Dr. Bruhns, who is the first Director of the new Observatory at Leipzig, has also published

Geschichte und Beschreibung der Leipziger Sternwarte, zur Eröffnung der neuen Sternwarte am 8 November 1861, herausgegeben von Dr. C. Bruhns. Mit fünf lithographirten Tafeln. Leipzig, 1861.

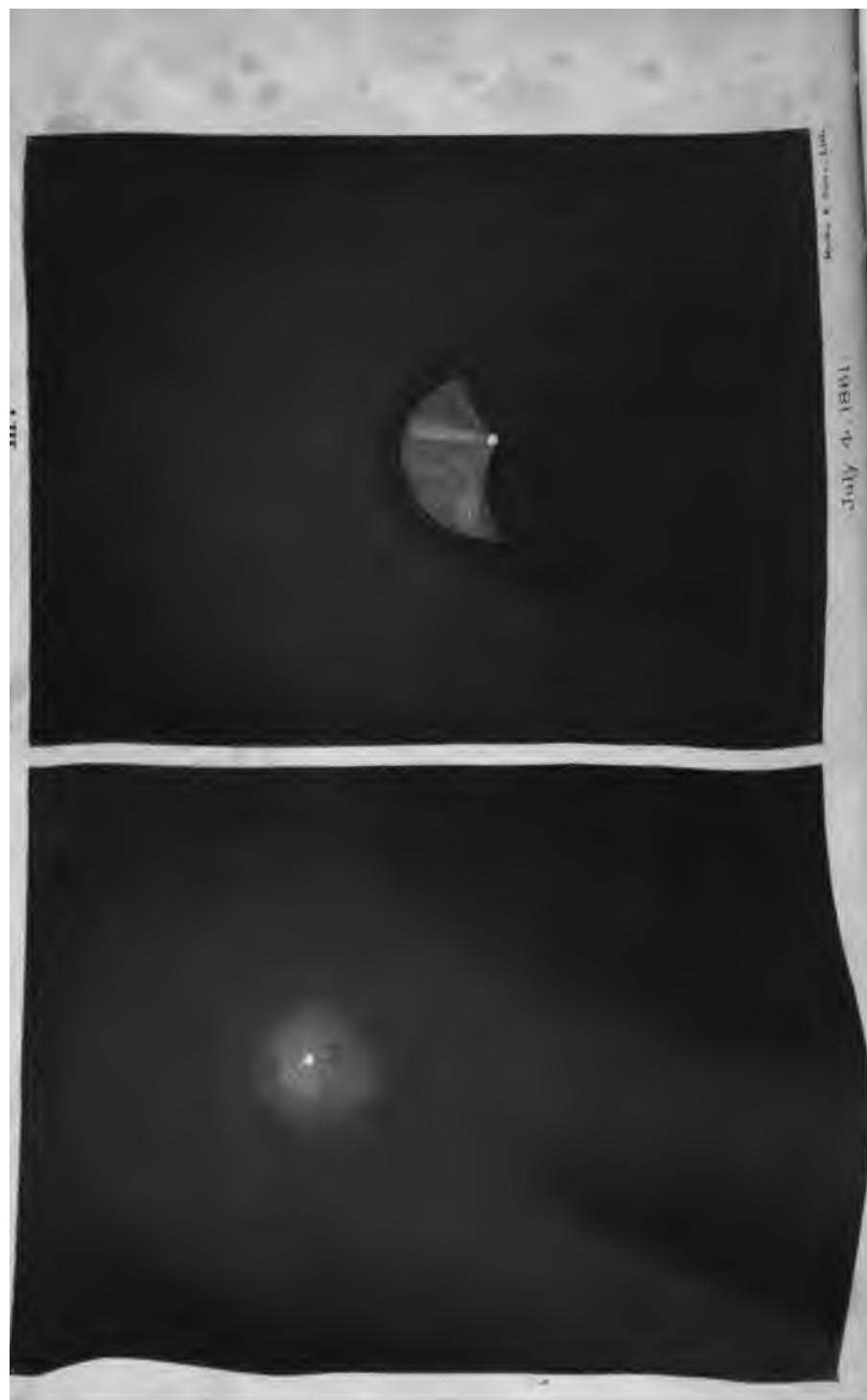
The new Observatory is situate near the town, in a somewhat elevated position in the Johannisthal. The latitude and longitude, as deduced from those of the old Observatory of the

Pleissenburg, are—latitude $51^{\circ}20'9''\cdot8$ N., longitude $49^{\text{m}}33^{\text{s}}\cdot6$ E. from Greenwich. The detailed description of the instruments is reserved until the completion of the great Equatoreal in course of construction by Pistor and Martins, and the publication of the first volume of Observations.

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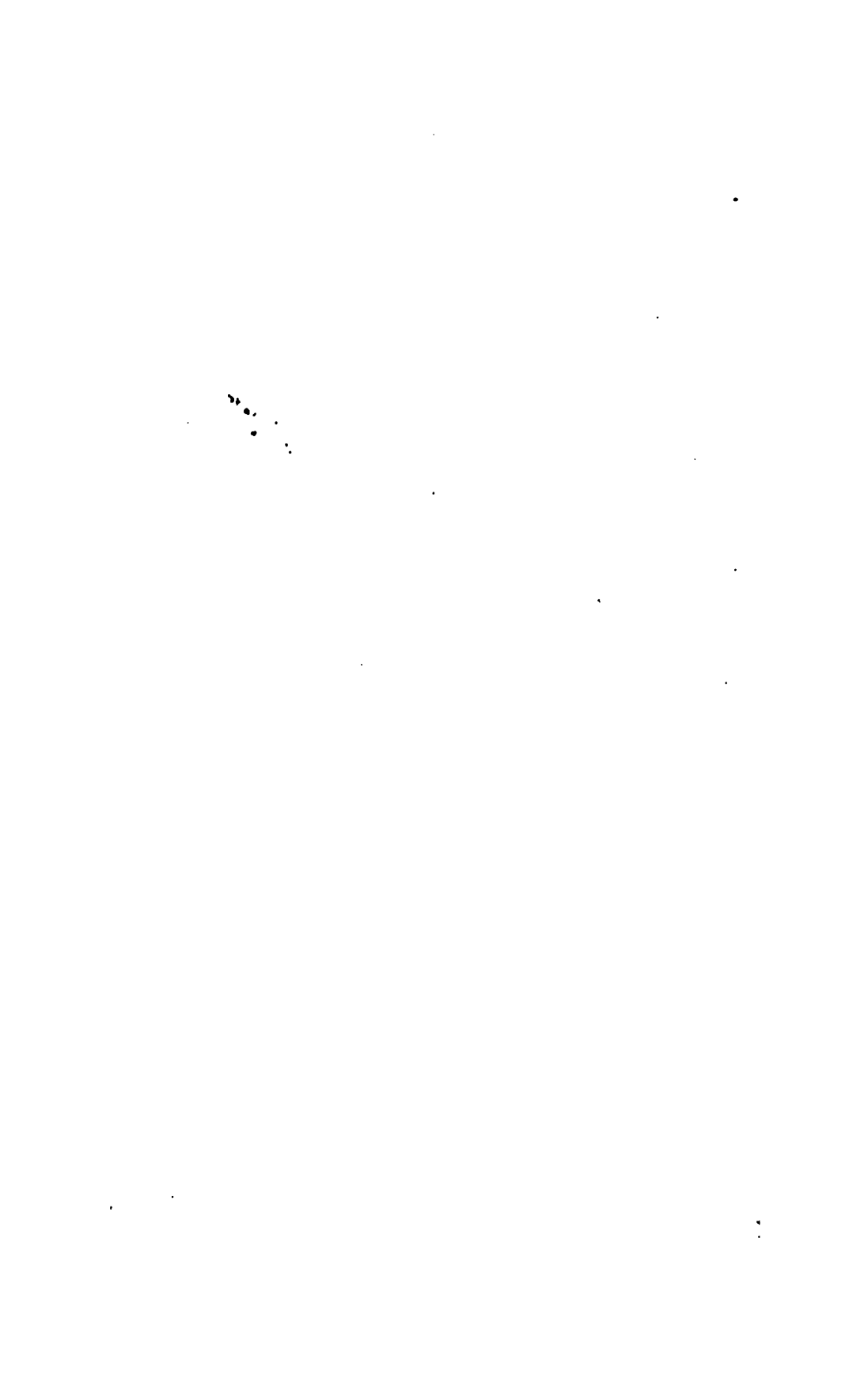
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Model No. 1000-1-1000

July 4, 1961



VIII.

V.

VII.



MONTHLY NOTICES
OF THE
ROYAL ASTRONOMICAL SOCIETY.

VOL. XXII.

Supplemental Notice.

No. 9.

*On the Great Comet of 1861.** By the Rev. T. W. Webb.

Though the observations which I was able to obtain of the physical aspect of the late splendid Comet are in several respects far from complete, I am induced to beg permission to submit them to the notice of the Astronomical Society, by the conviction that, in the case of objects so ill-defined and little understood, the accumulation and comparison of evidence will be likely to lead to a more satisfactory result upon the whole than might be attained, even under the most favourable circumstances, by any one observer, unaided and unchecked by independent testimony.

The observations which follow will be rendered more conveniently intelligible, if, instead of being retained in the form of a diary, they are arranged under separate heads, corresponding with the general structure of the comet.

The same telescope was employed throughout, having an excellent object-glass by Alvan Clark, of $5\frac{1}{2}$ -inches aperture, and 7 feet focal length.

I. *The Nucleus.*—On the evening of June 30, when, in common with the great majority of observers, I caught the first surprising view of this grand comet, the nucleus, a mere point in the comet eye-piece, and gradually opening and softening with increase of magnifying power, was expanded with about 460 into a fine luminous disc, estimated by a very rough guess at about $2''\dagger$ in diameter, having an uniformly distributed golden light, intermediate probably between that of *Venus* and *Jupiter*; and a very ill-terminated, but still definite, limb, which would, no doubt, have been much more distinctly marked at a higher altitude. It was quite circular, and showed no tendency whatever to a phasis.

* Comet II. 1861.

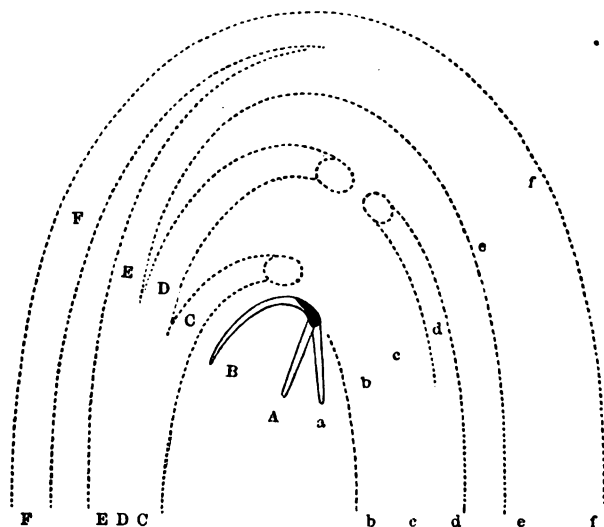
† This, I have since thought, was underrated.—T. W. W.

July 1 having been cloudy, on July 2 the nucleus was found to be equally brilliant, but already much smaller, and less abruptly distinguished from the adjacent luminosity, though the sky was not unfavourable.

July 3, in earlier twilight and a more vaporous atmosphere, the nucleus is entered as "small, dull, and ill-defined," with 460, though still a sharp and vivid point with 110.

July 4, the nucleus was estimated as not exceeding $0''.5$, but this was probably in defect; and it subsequently proceeded in a course of degradation, till, on July 15, it was "extremely dim and nebulous" with 460, and even with low powers, though still vivid, was evidently losing its sharpness.

II. *The Envelopes.* — The number and complex arrangement of these luminous veils on June 30, as seen in the comet eye-piece, with a field of about $52'$, and a power of 27, produced a singular as well as magnificent effect: it was as though a number of light, hazy clouds were floating around a miniature full moon. Portions of six could be more or less distinctly traced, as in fig. 1. The innermost of these (Λa in the key) was very narrow and short, faint on the left hand,



but brighter on the right in the inverted view, and coming up close to the nucleus. The second was a parabolic arc (Bb), in which the nucleus stood, but at some little distance from the vertex. The portion of it extending from the nucleus towards the inverted left, or orbitally following side, exhibited the most

vivid light of any of the envelopes, especially towards the nucleus, from which it seemed to issue straight out as an actual jet or stream, strongly luminous even with a power of 460. Its opposite branch beyond the nucleus was so much more faint and confused, that at the time its character was mistaken; it was not recognised as the prolongation of the same arc, which was erroneously, as I believe, referred to the right side (a) of the innermost envelope; nor was the mistake perceived till the next observation made the true structure of the head apparent, according to the best judgment which I could then form. It may here be remarked that these two interior veils were both in apparent contact with the nucleus, from which all the outer ones were clearly separated. The third envelope (cc) was only traceable on the left side, the opposite branch being merged in a diffuse haze. A little to the left of the probable direction of the radius vector it was kindled up into a small, bright, ill-defined cloud, more luminous than the rest of the curve, but not attaining the condensed light of the parabola next within it. The darkest portion of all the vacancies in the head was the space comprised between the left side of this envelope and the corresponding branch of the bright parabola within it, towards the visible termination of the latter. The 4th envelope (dd) took a considerably wider sweep: on the left hand it was confounded with the previous one, but arose out of it towards its vertex, leaving an interval of fainter light: on the right hand, according to the sketch taken at the time, the envelopes 2, 3, and 4, were all merged in one continuous veil, the outer and inner boundaries of which were alone distinguishable. Somewhere near the direction of the radius vector, as conjectured from the position of the innermost envelope, there was an indentation in the parabolic outline of dd, on each side of which there was a patch of more condensed light—that on the right was not very conspicuous, but the one to the left was much more luminous, exceeding in size and brightness the patch in the envelope cc, and forming a striking feature in the head: a line through this patch, and that in cc, passed far to the left of the nucleus. The 5th envelope (ee) was a faint, narrow stream, undistinguishable from dd to the left, but separated widely towards the right by the comparatively dark space which caused the indentation already mentioned in dd. Ff, the 6th, a similar narrow faint stream, had a distinct existence to the left, beyond a vacant interval, but was blended with the 5th towards the vertex of the parabola. Outside of these lay a great extent of scattered nebulous light on every side, fading gradually into the clear sky. None of the six envelopes could be traced for any distance backwards, all of them becoming speedily lost in the diffused train.

Fig. 5 represents the nucleus and brilliant jet, as seen with a power of 460; sketched, however, merely from memory.

On the next night of observation, July 2, the envelopes were found to be considerably changed, as in fig. 2, and still more confused on the right or orbitally preceding side of the head. Each branch of the first or innermost envelope was now equally faint: the great curve of No. 2 had become distinctly thicker, its prolongation beyond the nucleus continuing very dim: 3 and 4 were blended into one broad veil, all the luminous patches in them had faded, and the included area had become filled with nebulous light, stronger than the remoter parts of the head; the indentation in the outer boundary of No. 4 could be still traced, and the definite outline of the vertex of this envelope, contrasted with an exterior area of comparative darkness, was one of the most remarkable features of the head. This dark space was soon lost towards the right in confused nebulosity; its left end was at first supposed to be continuous with the broad vacancy exterior to the parabolic arc No. 2; but it was subsequently thought to be cut off from it by a feeble remnant of Nos. 3 and 4. Envelopes 5 and 6 were now combined into one broad veil, which passed away into the train.

July 3. I have no note of the aspect of the envelopes, having my attention drawn to other points, in a sky full of strong twilight and haze.

July 4. There is a comparatively dark and tolerably defined space in the head, as in fig. 3, exterior to the sector now formed, about one-third of its breadth, encompassing it as far as it is distinctly marked, and prolonged a little beyond it on the lower inverted side. Outside of this vacancy all is diffuse nebulosity, with some doubtful traces of streakiness, as if envelopes still existed there, not separately distinguishable. The orbitally preceding or south side is especially confused and ill made out.

July 5. The dark area is nearly obliterated, but the coma exterior to it seems streaky, as though composed of a number of narrow veils.

July 8. No envelopes remain.

III. *The Luminous Sector or Fan.*—This, as immediately connected with the nucleus, might have been described before; but, as its formation was at first incomplete, the observations may be more intelligible from its postponement. The first indication of its existence was the very intense light of that portion of the parabolic arc, or second envelope, which seemed to issue from the left side of the nucleus. This was very conspicuous in the first observation, and probably continued traceable, with little alteration, to the last. It has been drawn in fig. 1, as represented in the original sketch, coinciding with the external edge of the parabola; but I could not be confident as to this, not having expressly attended to the point; and from subsequent appearances it is more likely that it followed the interior curve of that envelope. It had not been noticed

in sketching with the low power of the comet eyepiece, about 27, but was clearly brought out with powers of about 110, 170, 275, and even 460, as a strong curved ray or vivid stream, actually emanating from the material of the nucleus, and gradually losing itself in the envelope.

July 2. The sector was more fully developed; in the comet eyepiece it was hardly discernible from the irradiation of the nucleus; but 110 brought it out beautifully, and it was visible even with 460. It extended, as in fig. 7, through about 125° : the upper inverted edge, which was the brightest part, and barely distinguishable from the nucleus at its origin, standing at an angle of about 190° ; the other edge, shorter, less defined, and apparently a little curved, at about 315° ; a portion of the included area preceding the nucleus was fainter than the rest. The extent of the upper cusp towards the Sun might be $\frac{1}{4}$ th of the distance from the nucleus to the indentation in the envelope No. 4.

July 3. The sector has a greater angular extent than last night, its edges standing at about 170° and 330° . It is very conspicuous in strong twilight, and has a radiated appearance, which had been suspected, but not verified, last night: the edge directed towards the Sun has lost its vivid light, and the brightest portion, which but little exceeds the rest, is a ray standing at about 225° , as in fig. 8. The edges sometimes appear a little concave.

July 4. The fan radiates like an electric brush, strongly reminding me of a similar appearance in the last return of the Comet of Halley. It must have gained considerably in breadth, as it is now well seen in the comet eyepiece. I estimate its extent at more than twice that of July 2. It is very well shown in the micrometer eyepiece, power about 55, with which some measures are attempted. The radius towards the Sun, so bright on July 2, has now become very feeble, and has also advanced in angular position, as in fig. 3; thence the area brightens to a distinct beam, with a thicker and denser extremity; next to this is a space of feeble light, running up far towards the nucleus; and, further on, the circular limb seems to be indented, so as to make the form of the north cusp sharp and long: an appearance increased by the backward curvature of the hinder boundary of the sector. But, excepting the beam with its broader end, which was sufficiently evident, these details were delicate and difficult. The measures of position, such as they were, gave for the south edge 207° (extremely uncertain), the luminous beam 251° , the north edge about 340° . The length of the beam, from its time of passage, appeared to be about $1\frac{1}{2}$ minute of arc.

July 5. The comet eye-piece showed the south edge of the fan more opened backwards, so that its position was more symmetrical; the luminous beam was broader, but less distinct.

July 8. The sector has nearly lost its circular boundary, and it fades down into the coma; but it is still visible, of a dull yellow hue, with 460: a mean of three bad measures of position gave for the south edge, 227° ; for the luminous beam, 271° .

July 10. The sector seems to stand as obliquely as in the last observation; its circular boundary has disappeared, and the stronger ray is very obscure.

July 15. Hazy; sector ill-defined, visible with 460, but contracted in angle, and of a brownish yellow hue.

July 16. Much clearer; the increasing density of the adjacent coma barely leaves a separate existence to the sector, which, however, in the present sky, has recovered its angular extent.

IV. *The Coma.*—This great mist faded away so imperceptibly that no attempt could be made to sketch its boundary; but I regret that I did not endeavour to form some idea of its extent at its first appearance.

On July 4 the whole diameter of the head was very roughly estimated at $20'$; July 10, $18'$; July 15, $13'$. My general impression, towards the close of the observations, was that it had increased in density and brightness as it diminished in extent: this seemed evidently the case on July 16, as, even with so high a power as 460, it was very conspicuous around and beyond the sector. Its most remarkable feature has been its change of colour. On June 30 the whole comet had a strong golden hue. July 10. I have entered it as distinctly white to the naked eye, and in the comet eyepiece tinged with blueish green or greenish blue. This hue was subsequently confirmed with suitable powers on the 15th, the nucleus appearing to have a greenish yellow cast. Considerable allowance must, of course, be made for the removal of the object from the ruddy vapour of the horizon, but still I think the fact of the change is at least highly probable.

V. *The Tail.*—This magnificent appendage was chiefly remarkable for its near approach to us, and consequent apparent length, being far inferior in density and definition to that of "the Donati."

On June 30 I traced it beyond the zenith, giving an extent of at least 90° . It widened out from the nucleus for some degrees, probably to a breadth of 3° or 4° , but was very undefined, and equally so on either side. The east edge appeared to strike off from the coma for a few degrees at a greater angle of divergency, but could not be traced by me as a separate branch; nor did I perceive, probably owing to the intervention of trees, the very interesting ray on that side, which, according to a communication and sketch with which I have been obligingly favoured by George Williams, Esq., of Liverpool, extended from the neighbourhood of the Comet's head as far as, and across, the stars of *Cassiopea*: the brightest part of

this beam, it is stated by the observer, was at some distance from the Comet, and it appeared to recede from it until it was altogether lost.* The main stream was considerably convex towards the west, pointing at its origin to the left of *Polaris*, and subsequently bending back so as to involve that star, which was in its centre about 11^h ; but thence it appeared to the eye of another person, as well as my own, to take a fresh course, directed straight from the nucleus towards β and γ *Lyræ*, its extremity being lost in the space marked out by α *Lyræ*, β and γ *Draconis*, and δ *Cygni*. Its general aspect is represented in fig. 6. By 13^h its edge had reached *Polaris*, but moonlight then began to enfeeble it. About $11^h 45^m$ my wife called my attention to a faint ray of perfectly similar character, stretching under the square of *Ursæ Majoris*, about 3° or $3\frac{1}{2}^\circ$ broad, having ψ *Ursæ Majoris* in its lower edge, and *Cor Caroli* about 1° above its upper, and traceable about half way from the latter star to *Arcturus*. It pointed to the Comet, but in the twilight no connexion could be made out. About 20^m afterwards it had risen higher, so as to stand midway between ψ and γ *Ursæ Majoris*; its further part had now become much more distinct than before, perhaps more so than any other portion of the ray, and its termination was plainly visible near ι *Boötis*; some time afterwards I could not see it. From this circumstance, and the character of its motion, opposite to that of the mass of the tail, I concluded it could be only a cirrus cloud brought up by the north-west wind, though the peculiarity of its direction caused me, fortunately, to record it; and from this impression, and my having missed the corresponding beam in *Cassiopea* (which, according to Mr. Williams, was somewhat the brighter of the two), I imagined for some time that the perspective appearance of the tail on this night did not accord with its immediate proximity, as calculated by Mr. Hind; but as the western ray was plainly seen by Mr. Williams at Liverpool about $12^h 30^m$, passing midway between α and β *Ursæ Majoris*, and reaching down towards the head of the Comet, I think there can be little doubt that it was really a part of the tail, whose rapid motion of closing up towards the axis indicated that it was then in the act of leaving the immediate vicinity of the Earth; and thus this most interesting appulse, if not actual conjunction, appears to have been verified by positive observation. Mr. Williams also had supposed that his two rays might be only streaks of cloud, and had been induced, like myself, to record them from the peculiarity of their direction: happily the intervening distance between the observers was such as to remove any suspicion of the kind. That gentleman's sketch, I ought also to observe, gives so great a breadth and so scattered a character to the central portion of the train, that it becomes naturally connected

* A copy of the sketch accompanied Mr. Webb's paper.—ED.

with these widely divergent lateral appendages. Under these circumstances it is not surprising that I should have failed in detecting any traces of a hollow structure, though I looked for them carefully. No anomalous ray could be perceived towards the Sun.

July 2. The tail was now slightly concave, instead of convex, towards the west; it could be traced nearly to *Wega*, or about 80° ; neither of its edges was at all defined. In the comet eye-piece its central region at some distance behind the nucleus appeared slightly fainter than its sides. Its general direction to-night coincided nearly with the right (inverted) side of the innermost envelope in fig. 2.

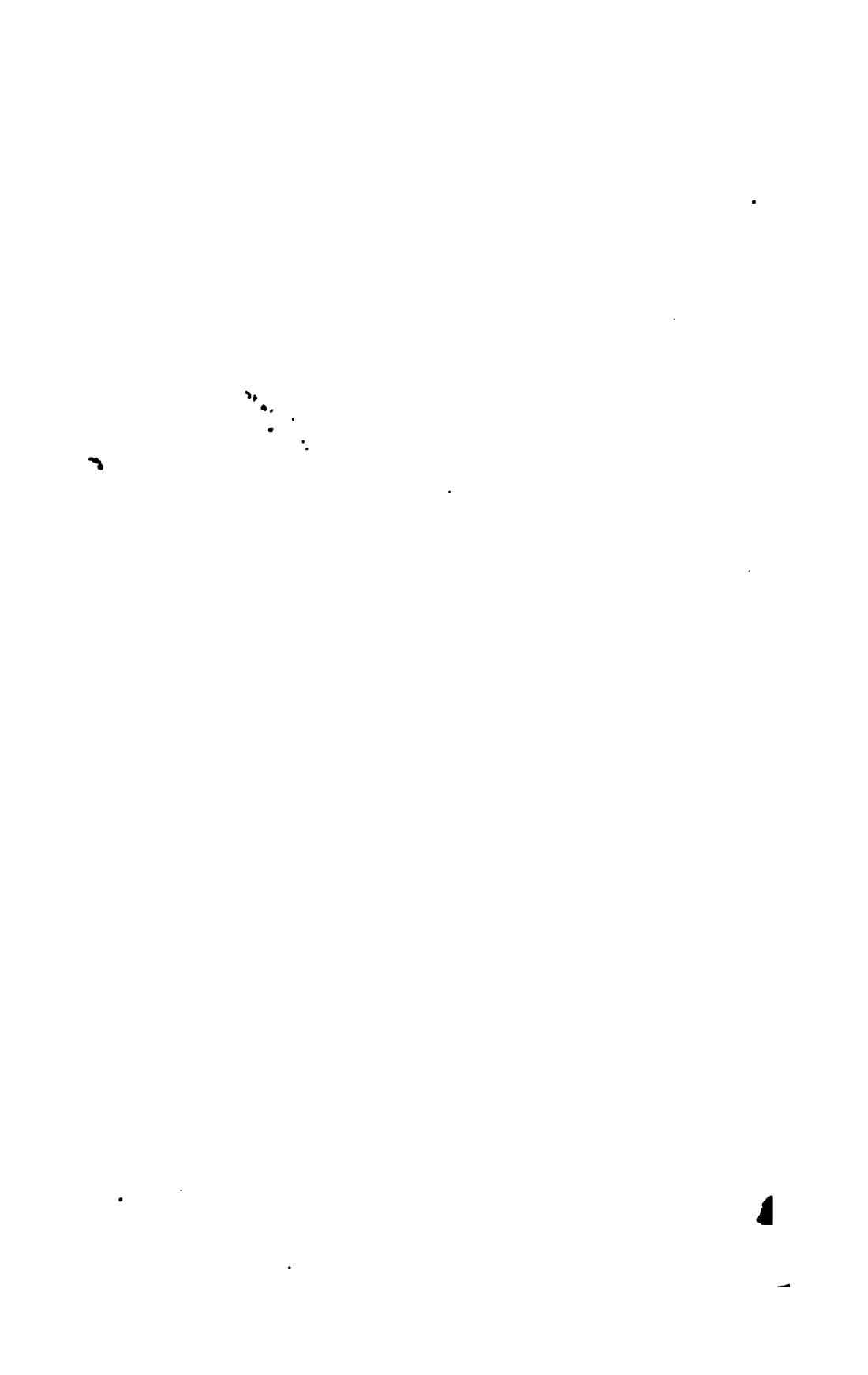
July 4. Tail nearly straight; possibly a slight double curvature, first to the left (or west), then to the right, but it is quite uncertain. It appears more dense for some distance from the head; both sides are equally ill-defined. The nucleus seems to stand at the vertex of a wide but very ill-marked parabola, part of which is formed by the north edge of the fan, and within which was rather less light than at the sides; the coma, in passing off along each side of this space to form the train, was somewhat brighter on the north; but all this was so indistinct as to require close attention, and nothing like two separate streams could anywhere be seen, nor was there any anomalous ray.

July 5. The tail appears, as last night, a little denser at its origin on the north, or orbitally following side; and rapid cross-sweeping with the comet eye-piece detects a slightly darker interior, commencing near the nucleus, but not traceable for any considerable distance.

July 6. The tail is again slightly turned to the left.

July 8. Tail about 14° or 15° , and streaky to the naked eye. I am not sure whether I have not noticed this before. In the comet eyepiece it had a narrow ray in the centre, or rather, a little way behind the coma, I saw nothing but a faint ray, about $5'$ broad by estimation, and several degrees in length. On the north side the coma passed off into a faint branch of about the same width, and perhaps $30'$ long., fading gradually away; on the other side I could find nothing corresponding. Hence I concluded that this branch and the longer ray were the two sides of a hollow tail, till further examination, and especially with the finder, convinced me to the contrary. In this little instrument the whole tail rose in one stream from the whole coma; and the ray, having been previously perceived, could be seen to form its axis for some distance. Fig. 4 is the appearance in the comet eyepiece; fig. 9 that in the finder.

July 10. I studied the tail carefully, and think that I misconceived its structure the night before last: the two branches, as in fig. 4, are, after all, a double train with a darker interior. I was misled by its coming off from the coma with a sudden



was such during these observations that it was not possible to obtain a fair view of the arrangement in the plane of its motion, or to form a satisfactory idea how far these phenomena may have arisen from any external resistance.

Hardwick Parsonage, December 24th, 1861.

Comet I., 1862.

The Comet appears to have been first observed by Mr. Schmidt, at Athens, about half-past ten on the evening of July 2, near the stars β , ϵ , σ , *Cassiopeiæ*. It was seen about midnight by M. Tempel, at Marseilles, and by Mr. Bond, at Harvard College, on the evening of July 3d (see *Ast. Nach.* Nos. 1369, 1370, and 1374). Elements have been computed by Dr. Seeling, Mr. Hall, Mr. H. P. Tuttle, and Dr. Weiss; those of Dr. Weiss, computed from the Athens and Marseilles Observations of July 2, 3, 5, are as follows:—

$$T = \text{June } 22^{\text{h}} 54^{\text{m}} 30^{\text{s}} \text{ G.M.T.}$$

$$\Omega = 324^{\circ} 30' 4'' \quad \text{Mean Eq.}$$

$$\Pi = 298^{\circ} 35' 2'' \quad 1862^{\circ} 0.$$

$$i = 8^{\circ} 14' 2''$$

$$\log q = 9.99242.$$

Motion retrograde.

Comet II., 1862.

The Comet was discovered by MM. Pacinotho and Tous-saint, at Florence, on the 22d July (*Ast. Nach.* No. 1374). The elements, as calculated by Dr. Hornstein, from observations of July 24, 27, and August 1, are as follows:—

$$T = 1862, \text{ Aug. } 23^{\text{h}} 7^{\text{m}} 13^{\text{s}} 95, \text{ Berlin M.T.}$$

$$\Omega = 137^{\circ} 4' 32'' 8 \quad \text{Mean Eq.}$$

$$\Pi = 344^{\circ} 16' 13'' 6 \quad 1862^{\circ} 0.$$

$$i = 66^{\circ} 3' 4'' 1$$

$$\log q = 9.9847732.$$

Motion retrograde.

Communications in reference to this Comet have been received from C. B. Chalmers, Esq., and Lieutenant Chimmo. Mr. Chalmers (Shanty Bay, County of Simcoe, Canada West), with his 5-foot equatorially-mounted telescope by G. Dollond, saw the Comet, August 11, about 10 P.M., in the constellation *Camelopardus*; approximate Declination $+80^{\circ} 51'$, Comet moving north at the rate of about $50'$ in twenty-four hours; there was no tail, but a rather extensive coma; the nucleus bore a faint illumination of the wires.

Lieut. Chimmo (Canna Island, Hebrides, lat 57° N., long. $6^{\circ} 30'$ W.) observed the Comet on the night of Sept. 1, about $9^h 51^m$ G.M.T. He observed the distances of the Comet from

Ursa Major α	$67^{\circ} 5' 30''$
Ditto η	$39^{\circ} 58' 30''$
Arcturus	$73^{\circ} 39' 30''$
α Lyre	$41^{\circ} 22' 30''$

from which the position is laid down on a drawing which accompanied his letter. The altitude was $25^{\circ} 48' 30''$.

The Moon had just set, and the Comet's position was made under the disadvantage of a bright Aurora, which was coruscating towards the zenith, from an arch of about 14° elevation, from N.N.W. to N.N.E. (mag.)

The tail of the Comet was inclined to the E.S.E. (mag.), and measured (with unassisted vision) half a degree nearly, or about equal to fifty millions of miles.

The nucleus was well defined, and equal to a star of the third or fourth magnitude, surrounded by considerable nebulousity of an irregular oval, perhaps paraboloidal. The jet apparently waved to and fro: this is however doubtful, and it may be an illusion, caused probably by the shooting coruscations of the Aurora.

The most attractive feature of the Comet was the well-defined limb of the south or underneath portion of the tail.

The instruments used were a common 3-foot telescope of 1.6 field, and a sextant, being all that the observer had; but there was the assistance of a pure and transparent atmosphere.

Hansen's Tables de la Lune.

A list, containing all the Errata discovered in the above Tables at the *Nautical Almanac* Office, and otherwise known at the Royal Observatory up to the date of March 10, 1862, has lately been issued in the form of a *Nautical Almanac*

Circular, and distributed from the Royal Observatory. All possessors of the Tables who have not received a copy of this list may obtain it on application to the Royal Observatory, Greenwich, or to the sources from whence they received the Tables.

Death of Capt. Jacob.

The Council have great sorrow in notifying to the Fellows of the Society the decease of Capt. Jacob, within a few days after his arrival in India, and that the important expedition on which he had set out is thereby brought to a most unexpected and unfortunate close. As the next Annual Report will contain fuller particulars of his life and labours, and in particular of this the closing event, the Council now confine themselves to stating that Capt. Jacob sailed from England in the Hertfordshire, by way of the Cape, on the 20th of April last; and after enjoying good health on the voyage, landed at Bombay on the 8th of August, with a slight cold, which appears from the accounts received to have been increased during the exertions of superintending the landing of his family and instruments. He proceeded, however, within two or three days to his destination, Poonah, where medical aid was called in, in consequence of an abscess in the throat and an attack of inflammation of the liver which had supervened. Leeches were very freely applied; and it is fruitless now to remark further than that, on the 16th, this admirable observer and excellent man was no more.

Another severe loss has been incurred by the decease of an Associate of the Society, the veteran Astronomer Carlini, who died in his 77th year, after a short but painful illness, on the 29th of August, 1862. An account of his life and scientific labours (carried on with unbroken activity for nearly sixty years) will be given in the ensuing Annual Report.

Mr. Dawes calls attention to some typographical errors in his paper, "Saturnian Phenomena," as printed in the last number of the *Monthly Notices*, viz., page 297, line 16 from the bottom, the word "*side*" should be in Roman letters, and page 298, line 7, the word "ring" should be in Italics; and line 38, the word "damp" should be "dense," the conjecture referred to being *the existence of a pretty dense atmosphere on the rings*.

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Solar Eclipse, July 18, 1860:—Two enlarged copies on glass of the Totality; Photographs; two ditto on paper, touched so as to show the first and last Phase; one paper copy, 4 inches diameter, showing the Phase imme- diately after the commencement of Totality, one minute after, and at the end of the Totality.	Warren De La Rue, Esq.
Six Photographs of the Sun, in a glazed frame.	Rev. S. Selwyn.
A Series of Drawings of the Planet <i>Jupiter</i> , from Observations made at Down's Road, Clapton, 4to. 1861	S. Gorton, Esq.
Three Drawings of Comets (Donati and 1861) in one frame.	Mrs. Hannah Jackson.
Troughton's Reflecting Circle and Stand, in two boxes.	Samuel Sharpe, Esq.

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- Albohazen Haly, *Præclarissimus in Judiciis Astrorum noviter impressum et fideliter emendatum*, fol. 1503
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